C.E.B.

Proceedings

of the

Twelfth Annual Convention

of the

American Railway Engineering and Maintenance of Way Association

held at the

Congress Hotel, Chicago, Illinois

March 21, 22 and 23, 1911

VOLUME 12

PART 2.

PUBLISHED UNDER DIRECTION OF THE COMMITTEE
ON PUBLICATIONS
1911

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C. B. BREED.

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American Railway Engineering and Maintenance of Way Association.

BULLETIN No. 132 FEBRUARY, 1911

REPORT OF COMMITTEE IV—ON RAIL.

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Rail presents the following report:

During 1910 the following meetings were held:

Baltimore, Md., February 16, 1910. Members present: Chas. S. Churchill, Chairman; R. Montfort, Vice-Chairman; R. Trimble, Secretary; E. B. Ashby, J. A. Atwood, A. S. Baldwin, M. L. Byers, W. C. Cushing, P. H. Dudley, C. H. Ewing, T. H. Johnson, H. G. Kelley, G. W. Kittredge, D. W. Lum, J. P. Snow, A. W. Thompson, Geo. G. Yeomans (representing F. A. Delano), M. H. Wickhorst, Engineer of Tests for the Committee.

The following representatives of the Manufacturers' Committee were also present:

F. W. Wood, President, Maryland Steel Company; W. A. Bostwick, Metallurgical Engineer, Carnegie Steel Company; E. F. Kenney, Metallurgical Engineer, Cambria Steel Company; S. S. Martin, Superintendent, Maryland Steel Company; P. E. Carhart, Inspecting Engineer, Illinois Steel Company; F. D. Carney, Assistant Superintendent, Pennsylvania Steel Company; C. H. McCullough, Vice-President and General Manager, Lackawanna Steel Company; H. C. Ryding, Assistant to Vice-President, Tennessee Coal, Iron & Railroad Company.

Birmingham, Ala., November 1 and 2, 1910.

Members present: Chas. S. Churchill, Chairman; R. Montfort, Vice-Chairman; J. A. Atwood, A. S. Baldwin, W. C. Cushing, Geo. G. Yeomans (representing F. A. Delano), John D. Isaacs, Thos. H. Johnson, M. H. Wickhorst.

During this meeting the Committee visited the mills and ore deposits of the Tennessee Coal, Iron & Railroad Company.

Chicago, Ill., November 29 and 30, 1910.

Members present: Chas. S. Churchill, Chairman; R. Montfort, Vice-Chairman; J. A. Atwood, A. S. Baldwin, J. B. Berry, W. C. Cushing, Geo. G. Yeomans (representing F. A. Delano), C. H. Ewing, Thos. H. Johnson, H. G. Kelley, C. A. Morse (representing J. W. Kendrick), J. P. Snow, M. H. Wickhorst, F. A. Delano, M. L. Byers.

During this meeting the Committee visited the steel plants of the Indiana Steel Company at Gary, and the South Works of the Illinois Steel Company.

In addition to the above meetings of the whole Committee other meetings of the various Sub-Committees were held.

VISITS TO MILLS.

The Committee visited the following rail mills during the year:

Tennessee Coal, Iron & Railroad Company, Ensley Mills, near Birmingham, Ala.

Indiana Steel Company (U. S. Steel Corporation), Gary, Ind.

Illinois Steel Company, South Works, South Chicago, Ill.

REVIEW OF PREVIOUS REPORTS.

In Bulletin No. 118, for December, 1909, all previous reports of the Committee were reviewed, and the record, therefore, brought up to date at that time.

1909: The Committee presented the statistics of rail failures:

(a) For the period of six months, from April 30 to October 31, 1908 (Vol. 11, Part 1, pp. 258 to 312), and

(b) For the period of six months, from October 31, 1908, to April 30, 1909 (Vol. 11, Part 1, pp. 313 to 386), and in these statistics are included the record of open-hearth and special alloy steel rails.

A series of photographs of characteristic rail failures is given in Vol. 11, Part 1, pp. 387 to 453.

The "Specifications for Steel Rails," heretofore printed in the Manual, were withdrawn and a new set of tentative specifications are printed in Vol. 11, Part 1, pp. 254 to 257, to serve as a guide in the preparation of future specifications.

A series of "Chemical and Physical Tests of Rail" was conducted by the Rail Committee at the Maryland Steel Company's plant, at Sparrows Point, Md., February 15, 1909, and the results were tabulated and described in Vol. 11, Part 1, pp. 454 to 493.

Mr. A. W. Thompson, Chief Engineer Maintenance of Way of the Baltimore & Ohio Railroad, presented a paper on general information concerning the sclerescope and its uses on the Baltimore & Ohio Railroad, described the use of titanium rail, and discussed rail failures due to burns and crystallization, caused by slipping of engine drivers on the same railroad, from pp. 494 to 559, Vol. 11, Part 1.

Some slight changes in the drop-testing machine specifications were recommended, on page 240, Vol. 11, Part 1, and some necessary changes were adopted in some of the forms for collecting rail failure statistics, as follows:

Form 2004-A, Summary of Steel Rail Failures.

Form 2004-B, Summary of Steel Rail Failures for a Period of Years.

Form 2004-C, Comparison of Rail Failures Between Different Steel Companies.

Form 2002-A, Report of Rail Failures in Main Tracks.

Form 2002-B, Superintendent's Monthly Report of Rail Failures.

Form 2003-A, Laboratory Report of Chemical and Physical Examination of Rails.

Form 2004-D, Position in the Ingot of Steel Rails.

The reason for the changes in Forms 2004-A, 2004-B and 2004-C was the adoption of a change in the unit of comparison, from failures in percentage of tons laid to "Number of Failures per 10,000 Tons Laid."

WORK DURING 1910.

The work outlined by the Board of Direction for the year was as follows:

(1) Consider revision of Manual; if no changes are recommended, make statement accordingly.

(2) Continue the investigation of the breakage and failure of rails and present summary of conclusions drawn from reports received.

(3) Report on the results obtained from the use of open-hearth and special alloy steel rails, and chemical composition of such rails.

(4) Present reports on the results of tests made in conjunction with the Manufacturers' Committee on the various kinds of rail, made by means of the special machines at the Pennsylvania Steel Company's mill and the Sparrows Point mill of the Maryland Steel Company.

(5) Report on any recommended changes in specifications for steel rails.

(6) Present recommendations on standard rail sections.

(7) Present report on rail joints, showing results of all tests at Watertown Arsenal, and recommend design and specifications.

(8) Reconsider and report any recommended change in standard drilling for rails, as given in the Manual.

(9) Make concise recommendations for next year's work.

(1) REVISION OF MANUAL.

It is believed by your Committee that the subject matter on "Temperature Expansion for Laying Rails," 1907 edition, page 53, belongs to Committee V, Track, and recommends that it be transferred to the chapter containing the recommendations of that Committee.

In view of subsequent changes adopted, it is recommended that the "Form for Reporting Rail Failures in Main Tracks, M. W. 1200," in the supplement to the Manual, Bulletin No. 103, pp. 16 and 17, be withdrawn and replaced by the accompanying form, M. W. 404, "Report of Rail Failures in Main Tracks."

This form has heretofore been numbered 2002-A, and it should be changed in accordance with the adopted system of enumeration.

The revision of this form was undertaken on account of the suggestion of Mr. C. E. Lindsay at the annual convention in March, 1910, that there ought to be a method for indicating the "Gage Side" of the rail, and this deficiency has been supplied by the addition to Question No. 39. At the same time, the numbering of questions was changed to eliminate the letters, and some of the questions were rearranged in what was thought to be a somewhat better order; otherwise, there have been no important changes in this form, and it has been found by experience to be well adapted to the purpose for which it was designed. The members of the Association will find it more convenient if they have this form made letter size instead of legal-cap size, as is the custom with some.

(2 AND 3) STATISTICS OF RAIL FAILURES.

The statistics of rail failures for the six months' period ending October 31, 1909, were published in Bulletin No. 121, of March, 1910, and were adopted at the last annual convention for publication in the Proceedings.

It was explained at the convention that the statistics were incomplete, owing to the desire to have them placed before the members, and in order to do this it was necessary to omit the statistics from a number of the principal railroad systems, as they were not received in sufficient time. After the convention these delayed reports were received by the Committee and it was decided that it was important to have them included. Therefore, the previous work in Bulletin No. 121 was thrown away and the statistics were retabulated and restudied entirely anew; consequently, the information in Bulletin No. 121 was not included in the Proceedings for 1910, and the revised information is published with this report as Appendix B.

These statistics also include information on the use of open-hearth and special alloy steel rails.

This information is the most complete on the subject ever published, and attention is called to the "Thoughts Resulting from the Study," on the last page of the text. It has been stated by some that they do not believe these statistics furnish any information of value, but your Committee believes that a careful study of the information will not warrant this conclusion. There are many hints to be derived from their study, and one of special importance is that differences in the production of ingots and the finished rail made from them may annihilate all advantages derived from any particular rail section. The design of rail section is not, therefore, the main cure for poor material.

At the last annual convention it was decided by the Association to have these statistics compiled annually thereafter, instead of semi-annually, as heretofore. The next annual period ends with October 31, 1910, and the Secretary of the American Railway Association has already sent out the circular and blanks for obtaining the statistics for tabulation. This compilation may not be ready for the annual convention in 1911, but the Committee hopes that it will be published in a Bulletin soon enough thereafter to obtain a letter-ballot of the Association, approving it, so that it can be included in the Proceedings for 1911.

In this connection Mr. W. C. Cushing has furnished the Committee with studies of individual or single rails which have failed in the main tracks, and these studies are made a part of this report, as Appendix D.

(4) EXPERIMENTS AND TESTS.

Mr. M. H. Wickhorst, the Engineer of Tests for the Committee, has been conducting experiments and tests under the direction of the Committee for the past year, and the results of his work are issued as Appendix E of this report. In connection with the eleven separate reports made by Mr. Wickhorst, a statement of the results believed to have been accomplished by this work up to the present time is furnished. The members are referred to this statement and the separate reports for detailed information.

The cost of this work has been borne entirely by the American Railway Association, and the appropriation made last year has been practically exhausted. The Chairman of your Committee appeared, however, in November, before the Committee on Maintenance and the Executive Committee of the American Railway Association and received an additional appropriation of $6,000 for continuing the work.

(5) SPECIFICATIONS.

On February 16, 1910, the Committee met with the Manufacturers' Committee, in Baltimore, and discussed a preliminary draft of the proposed new specifications. After this discussion some slight changes were made, although not all that were desired by the Manufacturers' Committee, and these specifications, as finally recommended by the Committee, were adopted as tentative by the Association at the annual convention in March, 1910. They are printed in Vol. 11, Part 1, pp. 254 to 257, but will not be included in the Manual. Of course, the principal work of this Committee is the preparation of a standard set of specifications for steel rail, and the large amount of data and statistics being published in these reports from time to time by the Committee are to enable the members of the Association, as well as the members of the Committee, to determine upon a set of specifications which will bring about the manufacture of "Good Steel Rails." The subject is a very intricate one and its study carries one back through all the processes of manufacture. It will, therefore, be readily seen that a large amount of time is required for this study, involving, as it does, the making of tests and the carrying on of experiments.

It is believed by the Committee that no rails have as yet been purchased under the tentative specifications referred to above, but the differences between them and the specifications used by some of the large railroad systems are not very great. They are being brought nearer together all the time.

Your Committee hopes to have enough information during the coming year to be enabled to make further recommendations with regard to them.

(6) RAIL SECTIONS.

No attempt has as yet been made by the Committee to design a new rail section, as many of the large systems have begun to use the two types, A and B, designed by the American Railway Association, and it has been thought advisable to obtain information derived from service, relative to these sections and others of special design, which may be in use, before making any new recommendations. These new designs are being watched, and it is hoped that in the course of time some definite information will be obtained. At present there are two parties, one favoring Type A, representative of the high stiff design with thin head, and the other Type B, representative of the lower and more flexible design, with heavy head.

In order to throw some light on the controversy between those representing the thin head, on the one hand, and the heavy head, on the other, Mr. Wickhorst made his study on the "Strength of Rail Head," in his report No. 9 of Appendix E. This study was intended also to give some information relative to the claim that the head of a rail is broken down by the excessive equipment loads of the present day, even though there be no physical defect in the interior of the rail head.

(7) TESTS OF RAIL JOINTS.

The first series of these tests, made at the Watertown Arsenal, were published in Bulletin No. 123, as Appendix A, and are to be regarded only as a progress report, as the entire series of tests have not been completed. Very guarded use should be made of the information in these tests, as the material in the different splice bars varies so widely that it is difficult to judge of the value of the different designs. The state of affairs is the same as in the case of the rail section, when your Committee pointed out that all differences in rail section can be annihilated by the quality of the material. This Bulletin should not be reproduced in the Proceedings until the tests have been completed.

(8) STANDARD DRILLING FOR RAILS.

This study has been commenced, but has not yet proceeded far. Only progress, therefore, is reported.

MISCELLANEOUS.

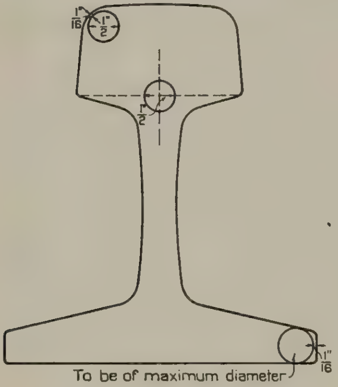
Mr. Churchill has made a valuable study, involving the compilation of a large number of tests, which is included with this report as Appendix C, "Statement of Drop Tests and Chemical Analyses of Rails Rolled for the Norfolk & Western Railway, giving Results of Various Heights of Drop on Rails of Known Composition, and a Comparison of Rail Analyses with Mill Analyses."

Other information of this kind has been furnished by the Pittsburgh & Lake Erie Railroad, the Louisville & Nashville Railroad, the Philadelphia & Reading Railway, the Boston & Maine Railroad and the Pennsylvania Lines West of Pittsburgh, which is now being studied by the Committee, and the results may be issued later.

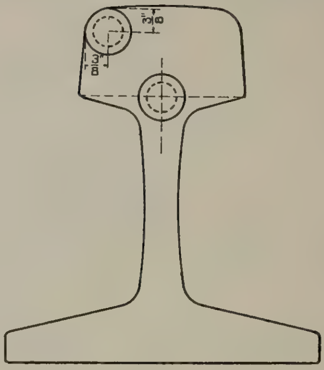
As the data from different persons was collected, it was discovered that comparisons were sometimes difficult, on account of lack of uniformity in the selection of the locations of borings for chemical analyses and of tensile test pieces. The Committee has, therefore, made a study of the question, and recommends that these locations be made standard. They are shown in the accompanying illustrations.

When an order of rail is being rolled by the mill, the reports made by the inspectors are very voluminous, and it is impossible to study them without tabulation. Furthermore, the tabulations made by different rail-

FOR CHEMICAL ANALYSES.

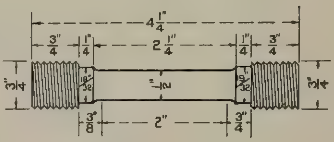


FOR TENSILE TEST PIECES.



NOTE

IF RAIL IS FLANGE WORN, THE BORINGS AND TEST PIECE FROM THE UPPER PART OF HEAD SHALL BE TAKEN FROM THE OPPOSITE CORNER.



AMERICAN RAILWAY ENGINEERING
AND
MAINTENANCE OF WAY ASSOCIATION.

STANDARD LOCATIONS OF BORINGS FOR CHEMICAL ANALYSES AND TENSILE TEST PIECES.

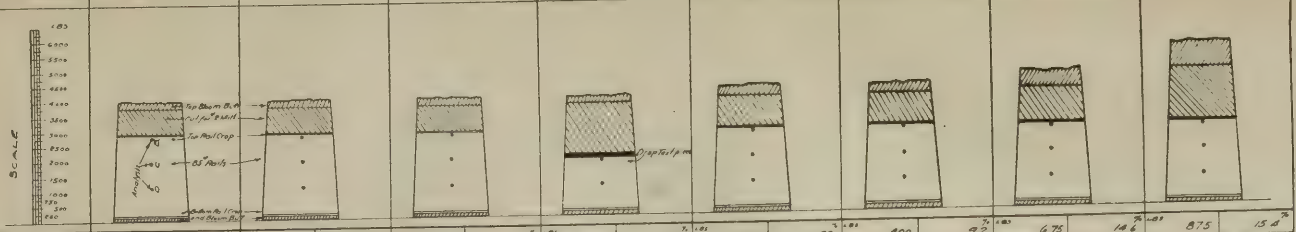
DEC. 20, 1910.

ANALYSIS OF E T HEAT No. 10939

ROLLED JUNE 24 1910 FOR VANDALIA R R UNDER
SPECIFICATION PENN L W OF PGH

Analysis & Inspection made by R. W Hunt & Co,

Office of Chief Eng. M of W, N W System.



INGOT No AS POURED	1		2		3		4.		5		6.		7.		8.	
	LBS	%	LBS	%	LBS	%	LBS	%	LBS	%	LBS	%	LBS	%	LBS	%
TOP BLOOM BUTT	225	54	225	54	225	54	225	54	400	92	400	92	675	14 6	875	15 4
CUT FOR No 2 MILL	850	204	850	204	850	204	1695	409	850	196	850	196	850	18 4	1700	30 0
TOP RAIL CROP	50	10	50	10	50	10	50	10	50	10	50	10	50	1 0	50	1 0
85 LB PS RAILS	2850	684	2850	684	2850	684	✱ 1985	479	2850	657	2850	657	2850	61 8	2850	50 3
BOTTOM RAIL CROP	65	18	65	18	65	18	65	18	65	16	65	16	65	15	65	10
BOTTOM BLOOM BUTT	125	30	125	30	125	30	125	30	125	29	125	29	125	27	125	23
TOTAL WEIGHT INGOT	4165		4165		4165		4145		4340		4340		4615		5665	

✱ Including drop Test piece 85 lbs

ANALYSIS / RAIL	B	C	D	B	C	D	B	C	D	LADLE	C	D	B	C	D	B	C	D	B	C	D	B	C	D
CARBON COMBN	578	512	.453	612	505	467	581	521	472	522	560	466	621	517	.485	576	522	468	524	514	470	537	485	470
PHOSPHORUS	111	096	086	109	090	088	104	.092	087	098	096	091	122	094	089	103	098	088	104	094	089	098	090	088
MANGANESE	104	105	104	102	103	105	104	103	100	101	104	103	107	103	103	103	102	102	102	101	102	103	103	103
SILICON	093	086	086	093	091	086	093	091	062	040	079	084	086	084	.093	.084	079	098	093	075	098	093	086	102
SULPHUR	081	065	047	085	065	.053	070	066	058	065	070	086	062	069	066	078	067	056	070	066	064	.070	052	040

HEAT No 10939

Time of blowing heat	15 Min
" " pouring from converter into ladle	1 Min 20 Sec
Spiegel added while emptying converter	
In ladle 1 Min 55 Sec before starting to pour Ingots	
Size of nozzle about 2"	
Time pouring 8 Ingots	6 Min
Started to Strip Moulds 52 Min after stopped pouring	
Time required to Strip	5 Min
First Ingot charged to Pits 8 Min after Stripping	
Ingots in soaking Pits	1 hr 20 Min
Bloomed in 7 passes to 9-3/4" x 9-3/4"	
Blooms in reheating furnaces	14 Min.
13 passes in Rail Mill train	
Rails rolled for Vandalia R R under Penn L W of Pgh specifications and Mill practice	

DESCRIPTION –
Each Ingot in the Order as poured from the ladle, is shown to the scale Indicated
After blooming the Ingots were divided relatively as shown, the weights being given in the table
Three 85 lb PS 33 ft rails, stamped B C and D were made from each Ingot, excepting
No 4 which Carried the drop Test piece and made but two rails, C and D
The Analysis from each rail was made on Samples taken from the bolt Holes drilled in the end of the rail toward the top of the Ingot, at approximately the location shown by the dots above.

Heat #10939 made and rolled June 24, 1910 Weight 35600 lbs
Size Ingots at bottom 18½ x 19½. Size blooms 9¾ x 9¾ 20 Passes Ingots to rail.
Made 23 rails, all No 1 33 ft except 2 D 6C 7C, flaws out top flange or Head Cuts,
7D, made #2 flaw Top flange and 3D (cut for butt end)
Ladle Analysis made on Test Ingot taken Taken as No 4 was poured
Drop Test 2000 lbs, 15 ft fall, 3 ft supports, deflection 1¾"

way companies are not comparable, unless made in the same form. The Committee has found it necessary to adopt a form for this purpose, and the one illustrated herewith is recommended for approval by the Association for the present. It may be found that changes in the future will be required.

In view of the changes on the back of M. W. 404, above outlined under "Revision of Manual," it is necessary to change the back of M. W. 405 (old No. 2002-B), Superintendent's "Report of Rail Failures," so that the arrangement will be the same. This is also illustrated by a drawing.

A study of a complete heat of Bessemer steel has been made under the direction of Mr. Trimble, and is submitted herewith for the information of the members.

A tabulated statement of the different practices in connection with rail rolling in American mills has been compiled and is submitted herewith for the information of the members.

AMERICAN STEEL RAIL MILL PRACTICE.

Compiled by Robert W. Hunt & Co.

MILL	LOCATION	KIND OF STEEL	NO OF CONV OR FURNACES	SIZE OF INGOTS AT BOTTOMS	NOM NO INGOTS PER HEAT	NOM NO 90# RAILS PER INGOT	BLOOM MILL ROLL HIGH	NOM. NO PASSES BLOOM MILL	BLOOMS RE-HEATED	NO OF PASSES RAIL MILL TRAIN	TOTAL PASSES INGOT TO RAIL	NO. OF HOT SAWS	NO EXTRA HOT SAWS	DIS FROM FIN ROLLS TO NEAREST HOT SAW OR ONE COM USED	*SEC TIME BETWEEN 1st SAW AND LEAVING FIN ROLLS	BRAND ON TOP OR BOTTOM
ALGOMA STEEL CO	ST STE MARIE CANADA	BESS O H	2 3	18 × 19½	2 15	4-5	2	17	YES	11	28	1	1	113'	25-30	BOTTOM
BETHLEHEM STEEL CO	BETHM, PA	O H	10	19 × 23	25	6	2	15	NO	11	28	1	1	270'	35-40	"
CAMBRIA STEEL CO	JOHNSTOWN PA	BESS O H	4	19¾ × 22¾	4	5	2	15	YES	12	27	4	0	77'	15-20	"
CARNEGIE STEEL CO	BRADDOCK PA	BESS	4	18½ × 19½	7-8	4-5	3	7	YES	13	20	4	0	43'	12-16	"
COLORADO FUEL & IRON CO	PUEBLO COL	O H	12	18 × 20	30	4	2	15	NO	10	25	1	0	105'	25-30	TOP
DOMINION IRON & STEEL CO	SYDNEY N S CAN	O H	10	18½ × 21½	18	8	2	17	NO	11	28	1	0	107'	10-15	BOTTOM
ILLINOIS STEEL CO	GARY IND	O H	28+	20 × 24	24	7	3-2	9	NO	9	18	5	0	158'	12-18	"
ILLINOIS STEEL CO	SO CHICAGO ILL	BESS	3	18½ × 19	6-7	4	3	9	NO	9	18	5	0	96'	10-15	"
LACKAWANNA STEEL CO	BUFFALO NY	BESS O H	4	19 × 19	6	4	2	6	NO	9	15	1	1	232'	12-18	"
LORAIN STEEL CO	LORAIN O	O H	6	22 × 26	20		2		YES							"
MARYLAND STEEL CO	SPARROWS PT MD	BESS O H	3 5	19 × 21	6 18	5 6	2	13	NO	11	24	1	1		28-32	"
MONTEREY STEEL CO	MONTEREY MEX															
PENNSYLVANIA STEEL CO	STEELTON PA	BESS O H	3 5+	18½ × 18½	30	4	3	9	YES	11	20	2	1	8'	10-14	TOP
TENN COAL IRON & R R CO	ENSLEY ALA	O H	8	19 × 23	30	6	2	11	NO	10	21	4	0	113'	15-20	BOTTOM

Figures above represent nominal practice.

Lorain rolls chiefly girder and high tee-rails.

In two high blooming mills rails may be given more than No. passes above.

Pennsylvania above is for standard sections only.

Tennessee is duplex process steel.

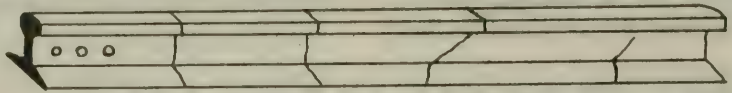
Dominion is duplex process steel.

Maryland may be duplex process steel.

Carnegie may roll O. H. from Homestead.

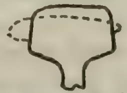
NOTE.—*Refers to time consumed from rolls until first rail is cut.

come under this head.

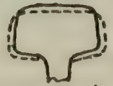


DEFECTIVE.

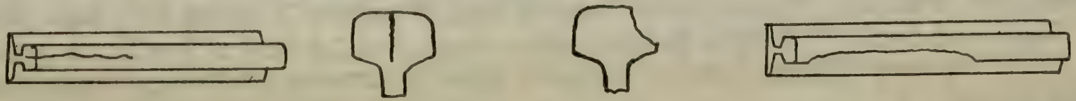
2. **FLOW OF METAL.** *This term means a "Rolling Out" of the metal on top of the head towards its sides without there being any indication of a breaking down of the head structure, that is, the under side of the head is not distorted.*



3. **CRUSHED HEAD.** *This term is used to indicate a "Flattening" of the head, and is usually accompanied by a crushing down of the head as shown in sketch.*



4. **SPLIT HEAD.** *This term includes rails split through or near the center line of the head, or rails with pieces split off the side of the head. When this term is used it should be further defined by stating whether it is or is not accompanied by a seam or hollow head.*



5. **SPLIT WEB.** *This term is a longitudinal split along the axis of the web, generally starting from the end of rail through the bolt holes.*

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.

M W 404

NO. ____________

____________ DIVISION. ____________ BRANCH.

Report of RAIL FAILURES in Main Tracks.

Section No. ____________ Date of Report. ____________ 191 __

1. Weight per yard, New ____ lbs. Re-rolled ____ lbs
2. Rail Section? ____________
3. Brand on Rail? ("D" on back) ____________
4. Kind of Steel? ("E" on back) ____________
5. Heat No. on Rail? ("F" on back) ____________
6. Rail No. or Letter? ("F" on back) ____________
7. Original Length of Rail? ____________
8. Month and Year Rail was laid? ____________
9. Location ______ Feet ______ of Mile Post ____________
10. Which Track? ______ Which Rail? ______
11. On Curve or Straight Line? ____________
11½ No. of Curve? ____________
12. Degree of Curve? ____________
13. High or Low Rail, if on Curve? ____________
14. Superelevation of Curve at "Break"? ____________
15. Was Rail "Broken"? ______ or "Defective"? ______ or "Damaged"? ______ (See "Description of Failures" on back).
16. Was Rail much or little worn? ____________
17. By whom discovered? ____________
18. Date and Time found? ____________
19. Was Rail removed? ______ Date removed? ______
20. Exact gauge of Track at "Break"? ____________
21. Was "Break" over or between Ties? ____________
22. Was "Break" square or angular? ____________
23. Distance between edges of Ties at "Break"? ____________
24. Condition of Ties each side of "Break"? ____________
25. Kind of Ties? ____________
26. Were Tie Plates used? ______ Kind? ______
27. Condition of Line and Surface? ____________
28. Kind of Ballast? ____________
29. Was Track properly ballasted? ____________
30. Kind of material in roadbed under ballast? ____________
31. Was Track well drained? ____________
32. Was Roadbed frozen? ____________

33. Condition of weather? (Wet, dry, warm or cold, freezing or thawing) ____________

34. If "Broken", state cause of break, and describe any flaws found at point of break. ____________

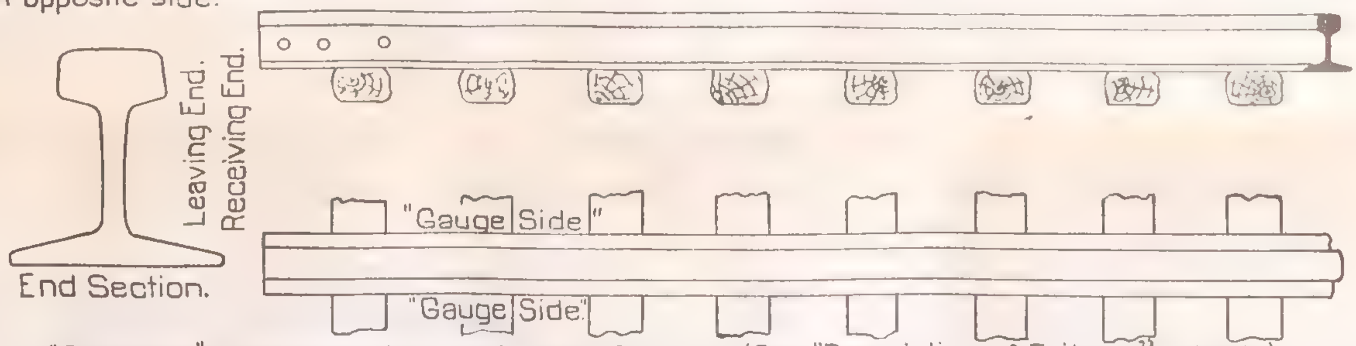
35. If "Break" was at Joint, state kind, number of holes, and whether it was full bolted or insulated. ____________

36. Were any bolts at joint loose? ______ If so, how many? ______

37. Was accident or detention to trains caused by "Break"? ______ If so, state circumstances. ____________

38. If "Defective", describe kind and location of flaws or defects, and if possible, what caused them. (See "Description of Failures" on back) ____________

39. Draw on Diagram lines of "Break", or partial fracture, such as long pieces from side of head and half-moon pieces from base, showing dimensions. Hollows in head should be shown on "End Section." Defects may also be indicated on diagram. Mark distance from end to "Break" * If "Break" is nearest "Receiving End", draw pen through words "Leaving End"; if nearest "Leaving End", draw pen through words "Receiving End". (* Refers to track upon which the current of traffic is in one direction.) Indicate "Gauge Side" on "Diagram" below, by drawing pen through words "Gauge Side" on opposite side.



40. If "Damaged", describe nature and cause if known. (See "Description of Failures" on back.) ____________

Correct: ____________ Foreman.

Approved: ____________ Supervisor

Instructions, and Description of Failures, on Back.

INSTRUCTIONS.

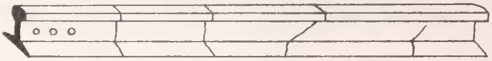
A. *The Division Engineer will make out two copies of this report at the end of the month from the Section Foremens' Reports, and send one copy to the Chief Engineer M. of W., and one to the General Superintendent.*

B. *Mile Post Number from {South East} end of Division to be used.*

DESCRIPTION OF RAIL FAILURES.

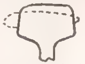
When describing Failures of Rails, the following terms should be used.

1. **BROKEN RAIL.** *This term is to be cofined to a rail which is broken through, separating it into two or more parts A crack which might result in a complete break will come under this head.*

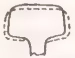


DEFECTIVE.

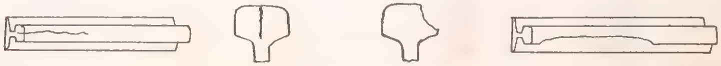
2. **FLOW OF METAL.** *This term means a "Rolling Out" of the metal on top of the head towards its sides without there being any indication of a breaking down of the head structure, that is, the under side of the head is not distorted.*



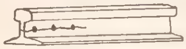
3. **CRUSHED HEAD.** *This term is used to indicate a "Flattening" of the head, and is usually accompanied by a crushing down of the head as shown in sketch.*



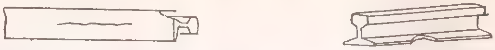
4. **SPLIT HEAD.** *This term includes rails split through or near the center line of the head, or rails with pieces split off the side of the head. When this term is used it should be further defined by stating whether it is or is not accompanied by a seam or hollow head.*



5. **SPLIT WEB.** *This term is a longitudinal split along the axis of the web, generally starting from the end of rail through the bolt holes.*



6. **BROKEN BASE.** *This term covers all breaks in base of rail*



7. **DAMAGED.** *Under this head will be included all rails broken or injured by wrecks, broken wheels or similar causes.*

INSTRUCTIONS.

A. *The Division Engineer will make out two copies of this report at the end of the month from the Section Foremens' Reports, and send one copy to the Chief Engineer M. of W., and one to the General Superintendent.*

B. *Mile Post Number from $\left\{\begin{matrix}\text{South}\\\text{East}\end{matrix}\right.$ end of Division to be used.*

DESCRIPTION OF RAIL FAILURES.

When describing Failures of Rails, the following terms should be used.

1. **BROKEN RAIL.** *This term is to be cofined to a rail which is broken through, separating it into two or more parts. A crack which might result in a complete break will*

G. *Mile Post No. from {South East} end of Division to be used.*

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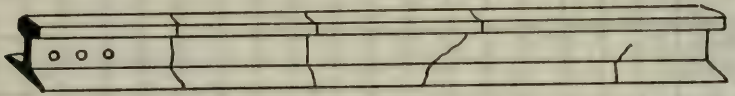

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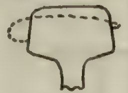

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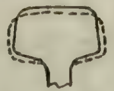

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AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION

MW 405.

.... Division

Sheet No of . Sheets

Superintendents Report of **Rail Failures** in Main Track for the Month of 19

Report Number	Description of Rail									Location of Rail.					Date Laid		Day of Month Found	Time in Service		Nature of Failure							In Splice	Out of Splice	Line No
	Weight per Yard	Type of Section	Marks on Rail						Lengths	Mile Post		Which Track	Curve or Tangent	Degree of Curve	Mo.	Year		Year	Mos.	Damaged	Broken	Flow of Metal	Crushed Head	Split Head	Split Web	Broken Base			
			Manufacturer	Rolled		Kind of Steel	Heat No.	Rail Letter		No.	Feet																		
				Mo.	Year																								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
																													1
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																													17
																													18
																													19
																													20
																			Total Failures →										
																				Grand Total of Failures for Month →									

Use following Marks for making entries in Columns.

In Column 4 use Car. for Carnegie. Ill.S.W. for Illinois, South Works.
Ill. G. for Illinois, Gary. Cam. for Cambria. Mar. for Maryland.
In Column 13 use E.B.P. for East Bound Passenger Etc
" " 14 " T. for Tangent. I.C. for inner rail on Curve. O.C. for outer rail on Curve.
" " 21-22-23-24-25-26-27 use fig. 1. to designate proper column.
Entries in Columns 21 to 27 should be repeated in Columns 28 or 29.

INSTRUCTIONS ON BACK.

Correct.

.... Division Engineer.

Approved.

.... Superintendent.

M.W. 4.432

INSTRUCTIONS.

A. *The Foreman will send this Report to the Supervisor the same day the break is discovered, and in the case of a damaged or defective rail, the day it is taken out of the track.*

B. *The Supervisor will forward this Report direct to the Division Engineer.*

C. *The Division Engineer will have copies of this Report made immediately upon receipt and send a copy to the Chief Engineer M. of W.*

D. *The answer to 3 is in raised characters on the web of the rail.*

E. *The answer to 4 is "Bessemer" (B); "Open Hearth", (O.H.); "Nickel" (N.); "Ferro-titanium" (F.T.); "Chrome Nickel" (C.N.) or other method of manufacture or alloy.*

F. *The answers to 5 and 6 are stamped into the metal on side of web; - figures for 5 and a letter for 6.*

G. *Mile Post No. from {South / East} end of Division to be used*

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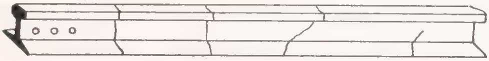

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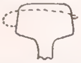

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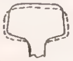

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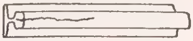
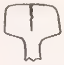
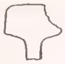
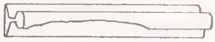

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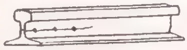
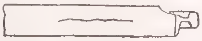
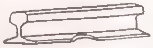
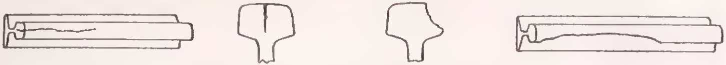


6. **BROKEN BASE.** *This term covers all breaks in base of rail and should be described and illustrated on sketches on front page.*

7. **DAMAGED.** *Under this head will be included all rails broken or injured by wrecks, broken wheels or similar causes.*

DEFE



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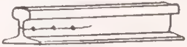

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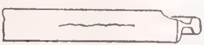

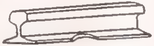

7. DAMAGED. *Under this head will be included all rails broken or injured by wrecks, broken wheels or similar causes.*

FORM M. W. 418.

RESULTS OF DROP TESTS AND SURFACE INSPECTION OF RAILS ROLLED.

FORM M. W. 418.

RESULTS OF DROP TESTS AND SURFACE INSPECTION OF RAILS ROLLED.

American Railway Engineering and Maintenance of Way Association.

RESULTS OF DROP TESTS AND SURFACE INSPECTION OF RAILS ROLLED DURING

Report Numbers	Heat Numbers

Width [illegible] inches

Lines	Name of Company and Mill where Rolled	Rail		Bessemer or Open Hearth	No. of Tons Ordered	No. of Tons Received of each Classification										No. of Tons Rejected		[illegible]	[illegible]	[illegible]	[illegible]	No. of Rails Accepted and Classification							No. of Rails Rejected		Average Analysis of Heats Accepted					Average Analysis of Heats Rejected					[illegible] Distance		[illegible]	[illegible]	[illegible]		[illegible]		Lines
						No. 1		Specials					No. 2									No. 1	Specials				No. 2																						
		Weight	Section			Tons	Total	A	B	C	D	Total	Tons	Total	Total Tons	Number						Rails	A	B	C	D					Carbon	Mang.	Phos.	Si.	Sulphur	Carbon	Mang.	Phos.	S.	Sulphur									
1																																																	1
2																																																	2
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13																																																	13
14																																																	14
15																																																	15
16																																																	16
	Grand Total																																																

These two columns are for office use in compiling the several rollings and shipments, and are to be removed on line "A" from the finished report.

A

NOTE

* Specials are not accepted columns 8, 9, 10 and 23, 24, 25, 26 should be omitted.

DROP TESTS

Drop Tests shall be made on pieces of rail rolled from the top of the ingot not less than four (4) ft. and not more than six (6) ft. long from each heat of steel. These test pieces shall be cut from the rail bar next to either end of the top rail as selected by the inspector.

The test pieces shall be placed head upward on solid supports five (5) in. top radius, three (3) ft. between centers, and subjected to impact tests, the tup falling free from the following heights:

70 lb. rail — 16 ft.
80, 85 and 90 lb. rail — 18 ft.
100 lb. rail — 20 ft.

The test pieces which do not break under the first drop shall be nicked and tested to destruction.

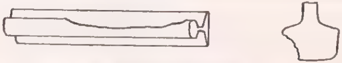
TESTS AND INSPECTION

(a) Two pieces shall be tested from each heat of steel. If either of these test pieces breaks a third piece shall be tested. If two of the test pieces break without showing physical defect all rails of the heat will be rejected absolutely. If two of the test pieces do not break, all rails of the heat will be accepted as No. 1 or No. 2 classification, according as the deflection is less or more, respectively, than the prescribed limit.

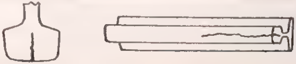
(b) If, however, any test piece broken under test (a) shows physical defect, the top rail from each ingot of that heat shall be rejected.

(c) Additional tests shall then be made of test pieces selected by the Inspector from the top end of any second rails of the same heat. If two out of three of these second test pieces break, the remainder of the rails of the heat will also be rejected. If two out of three of these second test pieces do not break, the remainder of the rails of the heat will be accepted, provided they conform to the other requirements of these specifications, as No. 1 or No. 2 classification according as the deflection is less or more, respectively, than the prescribed limit.

(d) If any test piece (test a) does not break, but when nicked and tested to destruction shows interior defect, the top rails from each ingot of that heat shall be rejected.



it into two or more parts



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RECOMMENDATIONS FOR WORK IN 1911.

As nearly all of the different items of work of the Rail Committee are leading up to the preparation of a standard set of specifications for steel rail and the design of a standard rail section, together with the appliances that go with the rail, and as these specifications and design have not yet been completed, it is recommended that the outline for the Committee's work during the coming year be the same as that for the past year.

Under item No. 4 the Committee desires to make a closer study of ingot making, as the principal defects connected with rail manufacture seem to have their origin in the making of the ingot. It is true that the temperature of the bar during manufacture and the amount of work done upon it have a strong effect on the subsequent quality of the finished rail, but the studies of your Committee lead it at present back to the ingot as the source of our most serious defects, viz: brittleness, unsoundness and segregation.

The Committee also hopes to study the relationship of the chemistry to the deflection under the drop, for the purpose of making a deflection formula, and in this connection it may endeavor to establish a relationship between the tensile strength and the elongation, or between the permanent set, as given by the drop test, and the elongation, so that the ductility of the metal shall be valued in the acceptance or rejection of the material, by means of a co-efficient, as has already been done by Professors Tetmajer and Dormus. Work in this line has already been done for the New York Central Lines by Dr. P. H. Dudley, and his own statement of his practice is submitted as Appendix F.

*CONCLUSIONS.

The Committee presents the following conclusions for your approval:

1. That the subject matter on "Temperature Expansion for Laying Rails," Manual, 1907 edition, page 55, be transferred to the chapter in the Manual containing the approved resolutions of Committee V, on Track.

2. That the "Form for Reporting Rail Failures in Main Tracks, M. W. 1200," be replaced in the Manual by form "M. W. 404, Report of Rail Failures in Main Tracks."

3. That the changes in Form M. W. 405 (old No. 2002-B) be approved, and the form included in the Manual.

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*For publication in the Manual.

4. That the drawing showing "Standard Locations of Borings for Chemical Analyses and of Tensile Test Pieces" be adopted and included in the Manual.

5. That the form for tabulating "Results of Drop Tests and Surface Inspection of Rails" be adopted and included in the Manual.

Respectfully submitted,

Chas. S. Churchill (*Secona Vice-President*), Chief Engineer, Norfolk & Western Railway, Roanoke, Va., *Chairman.*

R. Montfort, Consulting Engineer, Louisville & Nashville Railroad, Louisville, Ky., *Vice-Chairman.*

Robert Trimble (*Director*), Chief Engineer Maintenance of Way, Northwest System, Pennsylvània Lines, Pittsburgh, Pa., *Secretary.*

E. B. Ashby, Chief Engineer, Lehigh Valley Railroad, New York, N. Y.

J. A. Atwood, Chief Engineer, Pittsburgh & Lake Erie Railroad, Pittsburgh, Pa.

A. S. Baldwin (*Director*), Chief Engineer, Illinois Central Railroad, Chicago, Ill.

J. B. Berry, Chief Engineer, Chicago, Rock Island & Pacific Railway, Chicago, Ill.

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W. C. Cushing (*First Vice-President*), Chief Engineer Maintenance of Way, Southwest System, Pennsylvania Lines West, Pittsburgh, Pa.

F. A. Delano, President, Wabash Railroad, Chicago, Ill.

Dr. P. H. Dudley, Consulting Engineer, New York Central Lines, New York, N. Y.

C. H. Ewing, Superintendent, Atlantic City Railroad Company, Camden, N. J.

John D. Isaacs, Consulting Engineer, Harriman Lines, Chicago, Ill.

Thos. H. Johnson, Consulting Engineer, Pennsylvania Lines West, Pittsburgh, Pa.

Howard G. Kelley (*Past-President*), Chief Engineer, Grand Trunk Railway System, Montreal, Canada.

J. W. Kendrick, Vice-President, Atchison, Topeka & Santa Fe Railway, Chicago, Ill.

George W. Kittredge (*Past-President*), Chief Engineer, New York Central & Hudson River Railroad, New York, N. Y.

D. W. Lum, Chief Engineer Maintenance of Way and Structures, Southern Railway, Washington, D. C.

Jos. T. Richards, Chief Engineer Maintenance of Way, Pennsylvania Railroad, Philadelphia, Pa.

J. P. Snow, Chief Engineer, Boston & Maine Railroad, Boston, Mass.

A. W. Thompson (*Director*), General Manager, Baltimore & Ohio Railroad, Baltimore, Md.

M. H. Wickhorst, Engineer of Tests, Rail Committee.

Committee.

Appendices to Report of Committee IV—Rail.

(Published in Part 2, Vol. 12, of the Proceedings for 1911.)

Your Committee submits the following statements as Appendices to its report. They consist of:

(A) "Tests of Rail Joints of Watertown Arsenal," was published in Bulletin 123, and is to be considered as a progress report, no conclusions having been derived from it up to the present time.

(B) Rail Failure Statistics for Six Months' Period Ending October 31, 1910.

(C) Drop Tests of Rails; Deflection, Elongation and Compression; being a statement of Drop Tests and Chemical Analyses of Rails Rolled for the Norfolk & Western Railway, Giving Results of Various Heights of Drop on Rails of Known Composition and a Comparison of Rail Analysis with Mill Analysis.

(D) Studies of Individual or Single Rails Which Have Failed in Main Tracks, in two parts:

(a) A Study of 40 Rails.
(b) A Study of 68 Rails.

(E) Experiments and Tests by M. H. Wickhorst, as follows:

Reports Nos. 1 and 2. Tests of Bessemer Rails—Maryland Steel Company.

Report No. 3. Tests of Titanium Bessemer Rails—Lackawanna Steel Company.

Report No. 4. Tests of Bessemer Rails—Illinois Steel Company, South Works.

Report No. 5. Tests of Open-Hearth Rails—Gary Works.

Report No. 6. Tests of Bessemer Rails—Edgar Thomson Works, Carnegie Steel Company.

Report No. 7. Investigation of a Split Head Rail.

Report No. 8. Segregation as Influenced by Fire-clay on Ingot.

Report No. 9. Strength of Rail Head.

Report No. 10. Flow of Rail Head under Wheel Loads.

Report No. 11. Drop Tests of Rails, Effect of Impart Energy variously distributed.

(F) Ductility Tests of Rails under Specifications of the New York Central Lines.

Appendix B.

RAIL FAILURE STATISTICS FOR SIX MONTHS' PERIOD ENDING OCTOBER 31, 1909.

Submitted by Sub-Committee "C," W. C. Cushing, Chairman.

Statistics for this period were first published in Bulletin No. 121, but owing to the desire to have the report ready for the annual convention in March, 1910, the reports from a number of railroads, which were late in coming, were omitted.

After the convention it was decided by the Rail Committee that it would be advisable to retabulate the information, using all the reports which had been received in answer to American Railway Association Circular No. 966. Such answers were received from 71 railroads, and nearly all of them have been used in the preparation of the summaries and diagrams accompanying this report. The statistics are for the greater number of the large railway systems, and the number of tons reported are 7,445,825.

The information contained in Bulletin No. 121 will not be published in the Proceedings, but the present report will be printed in the 1911 Proceedings instead.

A statement is submitted, giving the names of the companies which have answered the circular, and showing whether the information was in shape for use or not.

The report consists of the following divisions:

(1) The tabulation of the information received from each company, tables 1 to 48.

(2) A summary by weights, sections and kind of steel, tables 49 to 59.

(3) A tabulation of data for diagrams 1 to 5, tables 60 to 72.

(4) A report of failures, classified according to the position in the ingot, tables 73 to 102.

(5) A report on the comparative wear of special rails, tables 103 to 110.

(6) Diagrams 1, 2, 3, 4 and 5, showing the comparison of failures graphically for different studies.

(7) Drawings of rail sections referred to in the reports.

Report No. 17, February, 1911.

GENERAL SUMMARY (TABLES 1 TO 48).

In considering the number of failures, all lots less than 1,000 tons have been ignored, as they usually lead to exaggerated results. The number of failures range from 0 to 698 per 10,000 tons of new rail laid.

There were no failures reported for the following lots of rail:

100 lb.	A. S. C. E	Cambria	Bess	1903	on Penna. Lines West
100 lb.	P. S	Illinois	Bess	1909	on Penna. Lines West
100 lb.	A. S. C. E	Algoma	O. H	1907–1909	on Michigan Central
100 lb.	Dudley	Lackawanna	O. H	1908	on New York Central Lines
100 lb.	P. S	Carnegie	O. H.-A	1909	on Penna. Lines West
100 lb.	P. S	Carnegie	O. H.-B	1909	on Penna. Lines West
90 lb.	A. R. A.-B	Illinois	Bess	1909	on B. & O.
90 lb.	Gt. Nor	Lackawanna	Bess	1908	on Great Northern
90 lb.	A. R. A.-A	Gary	O. H	1909	on B. & O.
90 lb.	A. R. A.-B	Gary	O. H	1909	on B. & O.
90 lb.	Gt. Nor	Penna	O. H	1908–1909	on Great Northern
85 lb.	P. R. R	Illinois	Bess	1895–1898	on Penna. Lines West
85 lb.	A. S. C. E	National	Bess	1901	on Norfolk & Western
85 lb.	A. S. C. E	Lorain	Bess	1900–1901	on Penna. Lines West
85 lb.	A. S. C. E	Carnegie	Bess	1905	on Rock Island Lines
85 lb.	A. R. A.-A	C. F. & I	Bess	1909	on A., T. & S. F.
85 lb.	A. S. C. E	Penna. Steel	O. H	1909	on Norfolk & Western
85 lb.	A. S. C. E	Bethlehem	O. H	1909	on Norfolk & Western
85 lb.	A. S. C. E	Gary	O. H	1909	on Rock Island Lines
85 lb.	P. S	Gary	O. H.-B	1909	on Penna. Lines West
80 lb.	A. S. C. E	Carnegie	Bess	1902–1903	on Houston & Texas Cent.
80 lb.	A. S. C. E	Maryland	Bess	1904–1907	on Houston & Texas Cent.
80 lb.	A. S. C. E	Carnegie	Bess	1899–1904	on Evansville & Terre Haute
80 lb.	A. S. C. E	National	Bess	1901	on L. S. & M. S.
80 lb.	A. S. C. E	Lackawanna	Bess	1907–1908	on Marquette & South East
80 lb.	A. S. C. E	Lack. & Ill	Bess	1906	on Munising Railway
80 lb.	A. S. C. E	Algoma	Bess	1902	on Michigan Central
80 lb.	A. S. C. E	Lorain	Bess	1902–1904	on Rock Island Lines
80 lb.	A. S. C. E	Illinois	Bess	1903–1905	on St. Joseph & Grand Island
80 lb.	A. S. C. E	T. C. & I	O. H	1905	on Big Four.
75 lb.	C. S	Carnegie	Bess	1896–1905	on Houston & Texas Cent.
75 lb.	C. S	Illinois	Bess	1907	on St. Joseph & Grand Island
75 lb.	B. & M	Lackawanna	Bess	1907	on Somerset Railway

NOTE: O.H-A contains phosphorus not to exceed .03 and carbon .70 to .83, while O.H-B has not over .04 phosphorus and carbon .62 to .75.

It should be borne in mind when considering the above, as well as what follows, that these records are for six months only, and in some cases the failures have not begun, while in others the poor rails have been pretty thoroughly weeded out.

The 698 failures per 10,000 tons were of the 90-lb. A.S.C.E. Chrome Nickel rail of the year 1909 on the Central Railroad of New Jersey (page 15), the chemical composition of which is not given.

There were 347 failures per 10,000 tons of 85-lb. P.S. Carnegie Bessemer 1909 rail on the Pennsylvania Lines West, with specified chemical composition as follows:

Carbon	.50
Phosphorus	.10
Manganese	1.00
Silicon	.12

This unfavorable showing was traced to a certain month's rolling, and it was found that there were a large number of bad heats during that month, the reason for which is not known. All of these failures were from a lot of 2,045 tons on the Northwest System of the Pennsylvania Lines West of Pittsburgh (page 25), and no such experience has been met with on the Southwest System, which received about the same tonnage of Carnegie rail of 1909 rolling.

The remainder of the rail failures of considerable numbers are given in the tabulated form below:

No.						
113 of	100 lb.	P. R. R.	Bess	1908–1909	Maryland	on P. R. R.
114 of	90 lb.	A. S. C. E	Bess	1903-1908	Carnegie	on P. & L. E.
102 of	85 lb.	P. S	Bess	1909	Carnegie	on P. L. W.
77 of	90 lb.	A. S. C. E	Bess	1907	Cambria	on C. R. R. of N. J.
61 of	90 lb.	A. S. C. E	Bess	1906	Lackawanna	on Big Four
66 of	90 lb.	A. S. C. E	O. H	1908–1909	Bethlehem	on C. R. R. of N. J.
63 of	90 lb.	A. R. A.-B	O. H	1908–1909	Bethlehem	on B. & O.
59 of	85 lb.	A. S. C. E	Bess	1898–1909	Carnegie	on B. & O.
73 of	85 lb.	C. B. & Q	Bess	1906–1907	Carnegie	on C. B. & Q.
57 of	80 lb.	A. S. C. E	Bess	1898–1908	Carnegie	on Big Four
56 of	80 lb.	A. S. C. E	Bess	1896–1904	Illinois	on Lake Superior & Ishpeming
87 of	80 lb.	A. S. C. E	Bess	1904	Carnegie	on Union Pacific
53 of	80 lb.	A. S. C. E	O. H	1906	Dom	on Grand Trunk
97 of	75 lb.	C. S	Bess	1905–1908	Various.	on Southern Pac.
85 of	90 lb.	N. Y., N. H. & H	Bess	1909	McKenna	on N.Y.,N.H.&H.

Taking all the reports which have been summarized on pp. 49 to 59, the failures are divided into Broken, Head Failures, Web Failures and Base Failures, according to the following precentages:

	Six Months Ending October 31, 1909.
Broken Failures	19%
Head Failures	66½%
Web Failures	8½%
Base Failures	6%

The above are divided for the different weights of rail, and between Bessemer and Open-Hearth steel, as follows:

Weight of Rail	Figures below are percentages of total failures							
	Broken		Head Failures		Web Failures		Base Failures	
	Bess.	O. H.	Bess.	O. H.	Bess.	O. H.	Bess.	O. H.
100	20	19	58	40¾	14½	28¼	7½	12
90	17	34	74	50¾	6	12	[illegible]	3¼
85	16	21¼	69¾	63¾	6¼	9	8	6
80	15¾	15	73	60	6¼	19	5	6
75	28	..	51½	..	17½	..	[illegible]	..

These figures do not show that the breakages of the heavy sections are fewer than the lighter sections, except in the case of 75-lb. rail. The head failures, however, of the 100-lb. rail seem to be materially less than those of 90 and 85-lb. rail. These figures furnish an example of how difficult it is to draw conclusions from general statistics where all the conditions are not the same.

DIAGRAM 1—COMPARISON BETWEEN DIFFERENT WEIGHTS OF RAIL, BESSEMER STEEL.

As for the previous period, ending April 30, the head failures are the most numerous, those for 90-lb. being slightly more numerous than for the others. Those for 85-lb. and 100-lb. come next, and are nearly the same.

The number of breakages is closely the same in all cases, while the web and base failures are quite insignificant.

DIAGRAM 2—COMPARISON BETWEEN DIFFERENT WEIGHTS OF RAIL, OPEN-HEARTH STEEL.

The head failures of the 80-lb. are the most noticeable. Nine companies furnished these statistics (table 94), as follows:

Central New England.
Grand Trunk.
New York, New Haven & Hartford.
Rock Island.
Big Four.
Nashville, Chattanooga & St. L. Ry.
Galveston, Harrisburg & San Antonio Ry.
Louisville & Nashville.
Southern.

Page 62 shows that nearly all of these failures were on the Grand Trunk and were of 80-lb. A.S.C.E. Dominion Iron & Steel Company 1906 rail, the chemical composition of which was:

Carbon	.55 to 0.65
Phosphorus	.06 (.05 obtained)
Manganese	.85 to 1.10
Silicon	.15
Sulphur	.05

The carbon is not high for the amount of phosphorus, but it is understood that the metal was quite badly segregated.

DIAGRAM 3—COMPARISON BETWEEN DIFFERENT SECTIONS OF RAIL, BESSEMER STEEL.

The information for this diagram is tabulated in tables 63 to 67.

The head failures of P.S. 85-lb. rail are the most noticeable, amounting to 35.8 per 10,000 tons laid, and the explanation already given is that they are principally from a lot of 2,045 tons, on the Northwest System of the Pennsylvania Lines West of Pittsburgh, of Carnegie 1909 rail. During the month these rails were rolled many defective heats were found, indicating that the failures were caused by the quality of the material, and not the rail section.

A moderate number of base failures is shown in the Great Northern 80-lb. rail, which is Illinois Steel of 1904 to 1907 rolling, containing:

Carbon	0.43 to .58
Phosphorus	0.10
Manganese	0.80 to 1.10
Silicon	0.20

There is nothing in the chemical constituents which would account for these special failures. A drawing of the rail has not yet been received, although requested.

The number of head failures have been listed below in their descending numerical order, and opposite each has been marked a letter indicating whether the section is heavy or thin head or of stiff or low design, using the A. R. A-A as the standard for thin head and stiff design, and the A. R. A-B as the standard for heavy head and low design; except in the case of 85-lb., the C.P.R. is used as the standard for thin head, the Dudley for the stiff design, and the P.S. for the heavy head and low design.

DIAGRAM 3.

Sec	Wt.	Tangent or Curve	Head Failures No.	Heavy or Thin Head	Stiff or Low Design
. S. (A.S.C.E.)	85	C	35.8	H	L
Cammell	80	C	16.1	H	L
A.R.A.-B	90	C	11.2	H	L
C. S.	75	T	9.7	T	S
C. S.	75	C	7.9	T	S
A.R.A.-A	90	T	7.8	T	S
P. R. R.	100	C	7.1	H	L
G. N.	80	T	6.8	H	L
P. S.	85	T	6 8		
A. S. C. E.	80	T	6.5	H	L
A. S. C. E.	90	T	6.4	H	L
G. N.	85	C	6.1	..	..
C. S.	90	T	5.9	T	S
A. S. C. E.	90	C	5.9	H	L
P S.	100	C	5.9	H	L
A. S. C. E.	100	T	5.7	H	S
B. & A.	95	C	5.4	..	..

It will be noticed that under this gage the A. S. C. E. 80-lb. and 90-lb. sections are heavy heads.

Of the 100-lb., the N. Y., N. H. & H. 100-lb. section makes the best showing, and it can be classed as a stiff section with heavy head.

The next best is the A. R. A-A 100-lb., and the next the A. R. A-B 100-lb., and then comes the Dudley 100-lb. of stiff design with thin head.

Of the 90-lb. the G. N. section makes the best showing.

Of the 85-lb. the A. R. A-A of stiff design with thin head and the P. R. R. of low design with heavy head are the best. Close to them is the C., B. & Q. of stiff design with heavy head.

Of the 80-lb. the best showing is made by the N. Y., N. H. & H., which turns out to be an A. S. C. E. section and is, therefore, of low design and heavy head, and the Dudley, which is of stiff design and heavy head.

The broken rails are comparatively few, the most noticeable being the C. S. 75-lb. and then the P. R. R. 100-lb. with heavy head.

DIAGRAM 4—COMPARISON BETWEEN SECTIONS OF RAIL, OPEN-HEARTH STEEL.

The information for this diagram is tabulated in tables 68 to 69. The head failures are the most numerous for A. S. C. E. 90-lb., G. N. 85-lb., C. S. 90-lb. and A. R. A-B 90-lb.

The A. S. C. E. 90-lb. rail is of Bethlehem manufacture on the B. R. & P. and the C. R. R. of N. J., while the 85-lb. G. N. and the 90-lb. C. S. are T., C. & I. Company.

There is considerable difference between the A. R. A-A and the A. R. A-B 90-lb., but by examining pp. 13 and 14 it will be found that the greater number of failures come from Bethlehem, which simply happens to be in this case A. R. A-B section. The failures of the same section of rails from the Gary mills are much less in number.

This last statement gives the clue to the real cause of failures, and further studying into these statistics will bring out this fact more strongly, viz.: that the cause of failures is the quality of the material, and not the design of the rail section.

Some of the most numerous failures in the case of Diagram 4 are tabulated below, as for Diagram 3.

DIAGRAM 4.

Sec.	Wt.	Tangent or Curve	Head Failures No.	Heavy or Thin Head	Stiff or Low Design
A. S. C. E.	90	T	16.7	H	L
G. N.	85	C	14.0	..	..
C. S.	90	C	11.1	T	S
A. R. A.-B	90	C	9.7	H	L
G. N.	85	T	9.0	..	..
A. S. C. E.	90	C	7.8	H	L
P. S.	100	T	6.2	H	L
A. S. C. E.	80	T	6.0	H	L

The A. S. C. E. heavy head, stiff design, C., B. & Q. heavy head, stiff design, and P.S. 85-lb. heavy head, low design, were all about the same.

There are no head failures for the N. Y., N. H. & H. 100-lb. of stiff design and heavy head, nor of the Dudley 100-lb. of stiff design and thin head. There are very few of the A.S.C.E. 100-lb. of stiff design with heavy head, and very few of the D., L. & W. 90-lb. with heavy head.

The broken rails are tabulated below in the same way.

Sec.	Wt.	Tangent or Curve	Broken	Heavy or Thin Head	Stiff or Low Design
A. S. C. E.	90	C	14.4	H	L
(A. S. C. E.) N.Y.N.H.&H.	80	T	10.3	H	L
D.L.&W.	90	C	7.1	H	L
A. S. C. E.	90	T	6.5	H	L

Of the Dudley 100-lb. no failures at all were reported, the material being from the Lackawanna mill.

DIAGRAM 5—COMPARISON OF FAILURES FOR DIFFERENT LENGTHS OF TIME.

The information for this diagram is tabulated in tables 70 to 72.

As is pretty generally known, most of the failures of any lot of rail occur during the first four years.

FAILURES WITH RESPECT TO THE POSITION IN THE INGOT (TABLES 73 TO 102).

The marking of the rails to distinguish the position in the ingot has become very general, as the increased number of the reports show, but, of course, the position of most of them is still unknown.

In general, the failures of "A" rails are the most numerous, but it is noteworthy that there are many failures down to "D" and "E," and occasional ones in "F." In some cases they are very numerous in the "D" rails.

REPORT OF COMPARATIVE WEAR OF SPECIAL RAIL (TABLES 104 TO 110). FERRO-TITANIUM ALLOY ON B. & O.

Some special rail containing the following composition:

Carbon	.701
Phosphorus	.086
Manganese	.92
Silicon	.079
Sulphur	.048
Nickel	.004
Titanium	1 to ½

was tried in comparison with ordinary Bessemer rail of the Maryland Steel Company on Kessler's Curve for twelve months and so far shows from one-fourth to one-third less wear than the Bessemer.

CHROME STEEL ON B. & O.

Some special rail with the following composition:

Carbon	.472
Phosphorus	.024
Manganese	.79
Sulphur	.062
Chromium	.21

was tried in comparison with ordinary Bessemer rail of the Cambria and Carnegie Steel Companies on the B. & O., but the results in each case are very closely alike.

NICKEL RAIL ON P. R. R.

There is nothing with which to compare the life of this rail. It was evidently not badly worn when taken out.

MAYARI RAIL ON P. R. R.

This seems to have lasted a little longer than the Open-Hearth rail, with nearly the same Carbon and Phosphorus, with which it was compared. It would seem that the Phosphorus is very low for the amount of Carbon. No Chromium content is shown.

MAYARI RAIL ON NORFOLK & WESTERN.

In the case of the high rail, the Mayari steel seems to have lasted better than the Bessemer, but in the case of the low rail it is not quite so good, though the difference is not great.

MANGANESE RAIL ON NORFOLK & WESTERN.

The test has been in progress for seven months, and in that time the Manganese rail is not half as much worn as the Bessemer.

NICKEL RAIL ON P. L. W., S. W. S.

This test has been finished. Half of the curve was usually laid with each kind of steel, so that when one kind was worn out it was necessary to remove the other also, and for that reason the Nickel rail in some cases was not entirely worn out. The Nickel and Bessemer were closely of the same composition, except that in the Nickel the Carbon was somewhat less and it had 3.44 per cent. nickel. The average of the various lots shows that the abrasion of the Bessemer rail was 20 per cent. greater than from the Nickel, indicating that much superiority for the Nickel. The failures of the Nickel were 45 in number, equivalent to 62 per 10,000 tons laid. Of the 45 six were broken, 19 had crushed heads and 20 split heads, indicating that the Nickel does not furnish a sounder ingot than Bessemer steel.

THOUGHTS RESULTING FROM THE STUDY.

(1) The study of these general statistics does not furnish accurate and specific information so as to determine the value of different sections of rail because:

(a) The conditions of traffic are different.

(b) The conditions of roadbed are different.

(c) The conditions of ingot making and rolling practice are so different that the quality of the material varies widely, and this difference in the quality of material eliminates differences in section.

(2) The study of these general statistics tends to disclose unusual results.

(3) The general statistics are also important in showing the relation between broken rails and failure of head, web and base.

(4) The tabulation of the statistics discloses the differences between steel companies when the sections and chemical composition are practically the same.

STATEMENT OF RAIL REPORTS RECEIVED FOR THE SIX MONTHS' PERIOD ENDING OCTOBER 31, 1909. COMPLETE AND PARTLY COMPLETE REPORTS USED IN SUMMARY BY SECTIONS, WEIGHTS AND KINDS OF STEEL; ALSO USED IN ALL DIAGRAMS, EXCEPT AS STATED.

Company	Used	Remarks
1 Atchison, Topeka & Santa Fe	Yes	
2 Atlantic Coast Line	Yes	
3 Baltimore, Chesapeake & Atlantic	Yes	
4 Baltimore & Ohio	Yes	
5 Baltimore & Ohio S. W	Yes	Except one report on form 2004-A, tons laid not given.
6 Bangor & Aroostook R. R	Yes	
7 Boston & Albany	Yes	
8 Boston & Maine	Yes	
9 Buffalo, Rochester & Pittsburgh	Yes	
10 Central New England	Yes	
11 Central R. R. of New Jersey	Yes	
12 Chesapeake & Ohio	Yes	
13 Chicago, Burlington & Quincy	Yes	
14 Chicago & Eastern Illinois	Yes	
15 Chicago & North-Western	Yes	
16 Cleveland, Cincinnati, C. & St. L.	Yes	Except report of O.S.Sec. 80-lb. rail, tons laid not given.
17 Cumberland Valley	Yes	
18 Delaware, Lackawanna & Western	Part	The parts giving tons laid, remainder in summary only.
19 Evansville & Terre Haute	Yes	
20 Fort Worth & Denver City	Yes	
21 Gal., Harrisburg & San Antonio	Yes	Harriman Lines.
22 Grand Rapids & Indiana	Yes	
23 Grand Trunk	Yes	
24 Great Northern	Yes	
25 Hocking Valley	Yes	
26 Houston & Texas Central	Yes	Harriman Lines.
27 Illinois Central	Yes	
28 Lake Shore & Michigan Southern	Yes	
29 Lehigh & Hudson River	Yes	
30 Louisiana Western	Yes	Harriman Lines.
31 Louisville & Nashville	Yes	
32 Maine Central	Yes	
33 Michigan Central	Yes	
34 Morgan's Louisiana & Texas	Yes	Harriman Lines.
35 Munising Ry	Yes	And Lake Superior & Ishpeming; Marquette & South Eastern Ry.
36 Nashville, Chattanooga & St. L.	Part	The parts giving tons laid, remainder in summary only.
37 New York Cent. & Hudson River	Yes	
38 New York, New Haven & Hartford	Part	The parts giving tons laid, remainder in summary only.
39 Norfolk & Western	Yes	
40 Northern Pacific	Yes	The parts giving tons laid, remainder in summary only.
41 Oregon R. R. & Navigation Co	Yes	Harriman Lines.
42 Oregon Short Line	Yes	Harriman Lines.
43 Pennsylvania R. R. Lines East	Part	The parts giving tons laid, remainder in summary only.
44 Pennsylvania Lines West	Yes	
45 Philadelphia & Reading	Yes	
46 Pittsburgh & Lake Erie	Part	The parts giving tons laid, remainder in summary only.
47 Rock Island Lines	Yes	
48 St. Joseph & Grand Island	Yes	Harriman Lines.
49 St. Louis & San Francisco	Yes	
50 Somerset Railway	Yes	
51 Southern Pacific	Part	The parts giving tons laid, remainder in summary only.
52 Southern Ry	Yes	
53 Temiskaming & Northern Ontario	Yes	
54 Texas & New Orleans	Yes	Harriman Lines.
55 Toledo & Ohio Central	Part	The parts giving tons laid, remainder in summary only.
56 Toledo, St. Louis & Western	Yes	
57 Union Pacific	Yes	
58 Vandalia	Yes	

Total, 58 companies.

STATEMENT OF RAIL FAILURE REPORTS RECEIVED FOR THE SIX MONTHS PERIOD ENDING OCTOBER 31, 1909.

Used in Summary by Sections, Weights and Kinds of Steel Only.

Company	Used	Remarks
Central Vermont....................	Yes	Does not give tons laid.
Chicago & Alton....................	Yes	Does not give tons laid.
Lehigh Valley.....................	Yes	Does not give tons laid.
Rutland R. R......................	Yes	Does not give tons laid.
Cincinnati, New Orleans & Texas Pac	Yes	Does not give tons laid or rail sections.

Total, five companies.
Grand total reports used, 63.

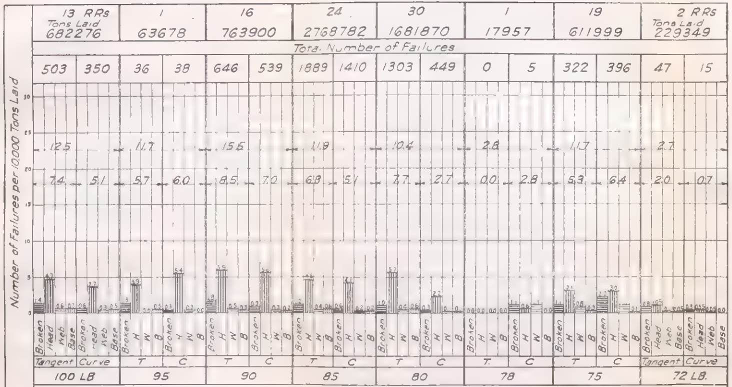
RAIL FAILURE REPORTS RECEIVED FOR THE SIX MONTHS' PERIOD ENDING OCTOBER 31, 1909.

Company	Not Used	Remarks
Alabama & Vicksburg..............	Not used	Does not give report on proper form.
Colorado Midland..................	Not used	No data. Arrangements made to furnish them hereafter.
El Paso & South Western	Not used	Gives record for one year instead of six months.
Georgia Railway....................	Not used	Failures not classified.
Long Island.........................	Not used	Form 2004-A not given.
Louisiana & Arkansas...............	Not used	Does not give years or tons laid.
New Orleans & North Eastern......	Not used	Form 2004-A not given.
Vicksburg, Shreveport & Pacific Ry.	Not used	Form 2004-A not given.

Total, eight companies.
Grand total companies reporting, 71.

DIAGRAM 1.

CLASSIFIED RAIL FAILURES — COMPARISON BETWEEN DIFFERENT WEIGHTS OF RAIL, BESSEMER STEEL, PERIOD OF SIX MONTHS FROM APRIL 30 TO OCTOBER 31, 1909.



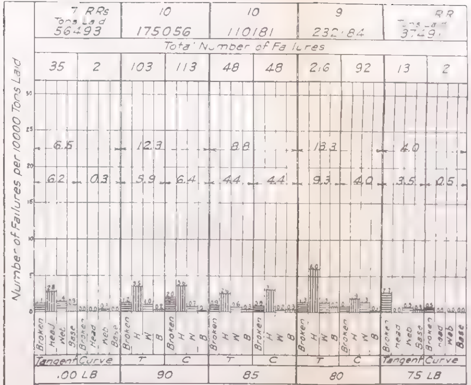
CLASSIFIED RAIL FAILURES DIAGRAM 1

Comparison between different WEIGHTS OF RAIL

BESSEMER STEEL

Period of 6 Months from April 30th to Oct 31st 1909

See Sheet Nos 60 & 61 for names of Railroads and Tons Laid



CLASSIFIED RAIL FAILURES DIAGRAM 2

Comparison between different WEIGHTS OF RAIL

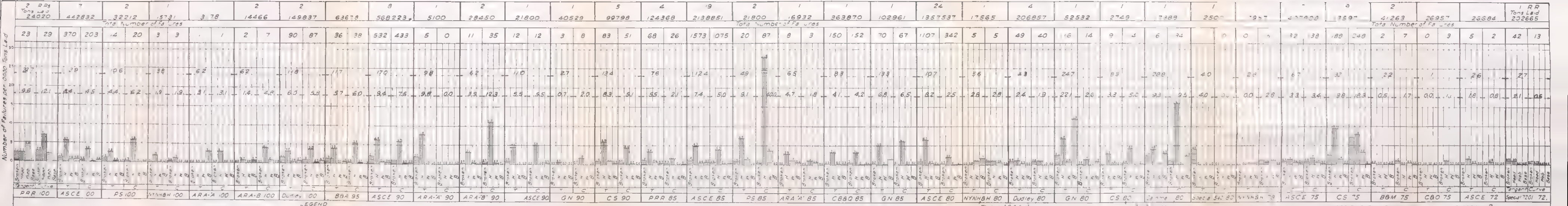
OPEN HEARTH STEEL

Period of 6 Months from April 30th to Oct 31st 1909

See Sheets Nos 62 for names of Railroads and Tons Laid

DIAGRAM 3.

ASSIFIED RAIL FAILURES—COMPARISON BETWEEN DIFFERENT SECTIONS OF RAIL, BESSEMER STEEL, PERIOD OF SIX MONTHS FROM APRIL 30 TO OCTOBER 31, 1909.



This is ASCE Sec

LEGEND

PRR – Pennsylvania RR
ASCE – Amer. Soc. of Civ. Eng's
PS – Pennsylvania System 1908
Dudley – P. H. Dudley
ARA A – Amer. Ry. Association Type A
ARA B – " " " " B
GN – Great Northern Ry
Special 540 – Hocking Valley RR

NYNH&H – New York New Haven & Hartford Ry
B&M – Boston & Maine RR
B&A – " & Albany RR
Special 720 – Chicago & North Western Ry
CB&Q – Chicago Burlington & Quincy RR
Cammel – Grand Trunk Ry
C&O – Chesapeake & Ohio RR
CS – Common Standard Union-Southern Pacific and Illinois Central Systems

See Sheets Nos. 63 to 67 for names of Railroads and Tons Laid

CLASSIFIED RAIL FAILURES

DIAGRAM 3

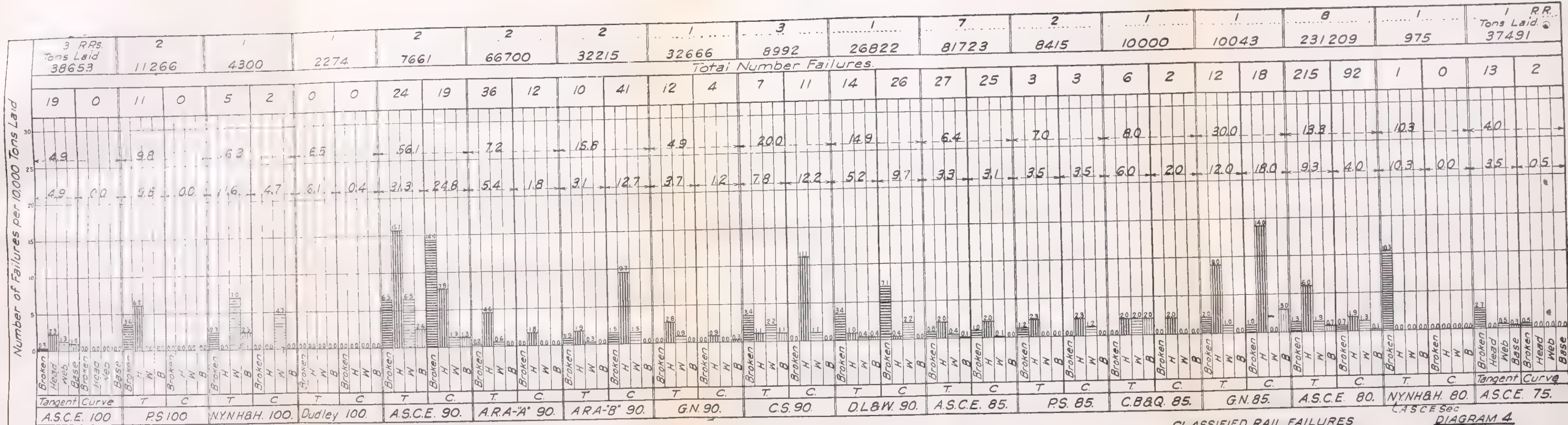
Comparison between different SECTIONS OF RAIL

BESSEMER STEEL

Period of 6 Months from April 30th to Oct. 31st 1909

DIAGRAM 4.

ASSIFIED RAIL FAILURES — COMPARISON BETWEEN DIFFERENT SECTIONS OF RAIL, OPEN-HEARTH STEEL, PERIOD OF SIX MONTHS FROM APRIL 30 TO OCTOBER 31, 1909.



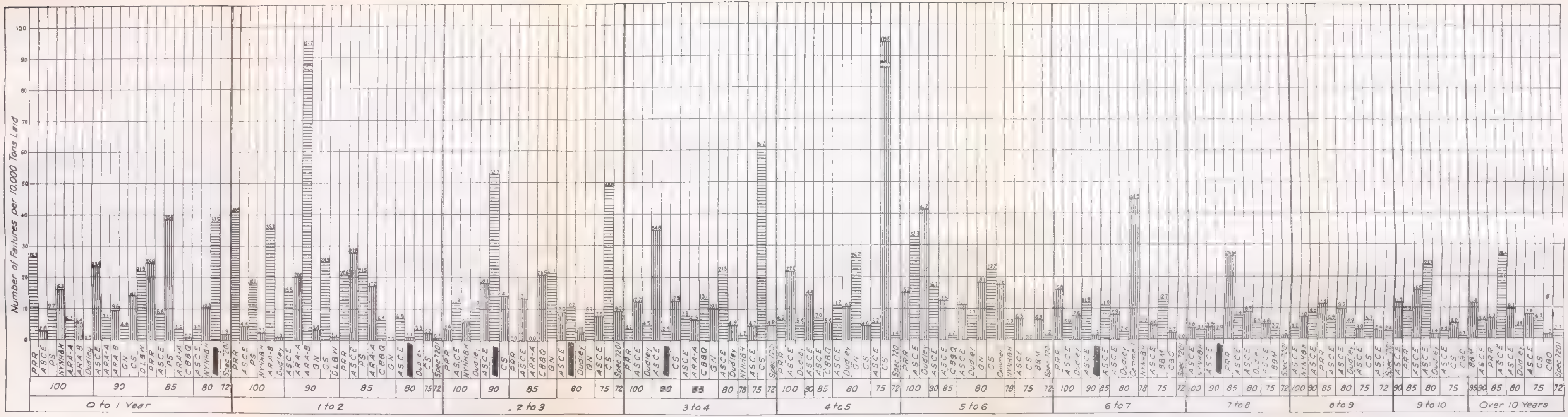
LEGEND.

A.S.C.E.—Amer. Society Civil Eng'rs.
PS—Pennsylvania System (New 1908).
Dudley—P.H. Dudley
A.R.A-"A"—Amer. Ry. Association "Type A"
A.R.A.-"B". " " " "Type B"
G.N.—Great Northern Ry.
N.Y.N.H.&H.—New York, New Haven & Hartford Ry.
D.L.&W.—Delaware, Lackawanna & Western R.R.
C.B.&Q.—Chicago, Burlington & Quincy R.R.
C.S.—(Common Standard.) Union-Southern Pacific and Ill. Central Systems.

CLASSIFIED RAIL FAILURES
DIAGRAM 4.
Comparison between different SECTIONS OF RAIL.
OPEN HEARTH STEEL.
Period of 6 Months from April 30th. to Oct. 31st 1909.
See Sheets Nos. 68 & 69 for names of Railroads and Tons Laid.

DIAGRAM 5.

ASSIFIED RAIL FAILURES — COMPARISON OF
FAILURES AT DIFFERENT LENGTHS OF LIFE,
ALL KINDS OF STEEL, PERIOD OF SIX MONTHS
FROM APRIL 30 TO OCTOBER 31, 1909.



LEGEND

PRR - Pennsylvania RR
ASCE - Amer Society Civil Engrs
PS - Pennsylvania System (New 1908)
Dudley - PH Dudley
ARA-A - Amer Ry Association "Type A"
ARA B - " " " "Type B"
GN - Great Northern Ry
CS - (Common Standard) - Union - Southern Pacific and Illinois Central Systems

NYNH&H - New York New Haven & Hartford Ry
B&M - Boston & Maine RR
7201 Special - Chicago & North Western Ry
DL&W - Delaware Lackawanna & Western RR
CB&Q - Chicago, Burlington & Quincy RR
Cammell - Grand Trunk Ry
C&O - Chesapeake & Ohio RR

CLASSIFIED RAIL FAILURES DIAGRAM 5
Comparison of Failures at different LENGTHS OF LIFE.
ALL KINDS OF STEEL
Period of 6 Months from April 30 th to Oct 31st 1909.

See Sheets Nos. 63 to 69 for names of Railroads and Tons Laid.

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with same period of previous year

100 lb. P.R.R. Section Bessemer Steel. Rolled by Various Steel Co. Record for period of ~~one year~~ ending October 31 1909

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
												Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang	Curve	Tang	Curve	Tang	Curve			
											%																	
								Maryland			No	Cumberland Valley																
1903											%	11	11					56	22									
1907	12158							46000	50400		No	1	1					5	2					6	3	9	11.1	7.4
											%																	
											No.																	
											%	Pennsylvania Railroad Lines East																
								Carnegie			No.																	
1908											%	11	33⅓						33⅓	22								
1909	4193	0.50	0.08	1.00	0.13			48350	56800		No.	1	3						3	2				3	6	9		21.7
											%																	
											No.																	
											%																	
								Carnegie			No	Pennsylvania Railroad Lines East																
1908											%	7	7		36				43		7							
1909	5634	0.50	0.08	1.00	0.12			48350	56800		No	1	1		5				6		1			1	13	14		24.8
											%																	
											No.																	
											%																	
								Maryland			No.	Pennsylvania Railroad Lines East																
1908											%	16	10			5	5			48	16							
1909	1677	0.50	0.08	1.00	0.12			62900	62900		No.	3	2			1	1			9	3			13	6	19		113.3
											%																	
											No.																	
											%																	
								Pennsylvania			No	Pennsylvania Railroad Lines East																
											%																	
1909	412										No										1				1	1		24.3

2

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of 6 Months ~~one year~~ ending October 31 1909

100 lb. ASCE Section Bessemer Steel Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail. *Millions*		Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
								Maryland			%																	
											No.	Baltimore & Ohio																
1901 1908	46695	0.45 0.55	0.10	0.85 1.15	033 0.20	0.056 0.075		40000	49000		%	10	4 4/10			17	34	10	19 6/10		2 3/10	2 3/10				41	17.6	8.8
											No	4	2			7	14	4	8		1	1		16	25			
								Cambria			%																	
											No.	Baltimore & Ohio																
1905 1907	20927	497 .502	098			.056 .061		23237	25083		%	5			3	22	30	8	14	5	5		8			37		17.7
											No.	2			1	8	11	3	5	2	2		3	15	22			
								Carnegie			%																	
											No.	Chesapeake & Ohio																
1902	8685							51000	48000		%															2		2.3
											No.	1	1											1	1			
								Maryland			%																	
											No	Chesapeake & Ohio																
1902 1908	10385										%															2		1.9
											No.	1						1						2				
								Illinois			%																	
											No.	Chicago Burlington & Quincy																
1907	2055	0.48 0.58	0.10	0.80 1.10	0.20						%					50		25				25				4		19.5
											No.					2		1				1		4				
								Carnegie			%																	
											No.	Lake Shore & Michigan Southern																
1905 1906	9575	0.45 0.55	0.10	0.75 1.05	0.20			50000	58400		%	10				30		40	10				10			10		10.4
											No.	1				3		4	1				1	8	2			
								Illinois			%																	
											No	Lake Shore & Michigan Southern																
1905 1909	121580	0.45 0.55	0.10	0.75 1.14	0.20			50000	58400		%	11	3			15	13	32	5 1/4	7	3/4	9	4			130		10.7
											No	14	4			20	16	42	7	9	1	12	5	97	33			
								Lackawanna			%																	
											No.	Lake Shore & Michigan Southern																
1905 1907	37189	0.45 0.55	0.10	0.75 1.05	0.20			50000	58400		%	6	3			28	4 1/2	38	7	3		7	3 1/2			111		29.9
											No.	7	3			31	5	42	8	3		8	4	91	20			
								Lackawanna		2.00	%																	
											No	Michigan Central																
1903 1909	56370	0.49 0.562	0.76 1.00	0.97 1.08	0.087 0.139	0.046 0.090		52000	48000		%	5	1 1/4					50	22 1/4	7	2 1/2	7	5			85		15.1
											No.	4	1					43	19	6	2	6	4	59	26			

____________As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

_100_ lb. ASCE Section Bessemer Steel. Rolled by Various Steel Co. Record for period of 6 months ~~one year~~ ending October 31 1909 3

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail. Millions		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
											%																	
								Algoma			No.	Michigan Central.																
1905 1909	39308	0.516 0.554	0.082 0.083	0.935 1.030	0.098 0.128	0.043 0.048		44000	47000	2.00	%	47						23		17		10	3			30	3.8	7.6
											No.	14						7		5		3	1	29	1			
											%																	
								Illinois			No.	Michigan Central																
1905 1909	47885	0.450 0.534	0.096 0.106	0.90 0.95	0.106 0.121			52000	48000	2.00	%	24	12				4	12	24			16	8			25	5.2	5 2
											No.	6	3				1	3	6			4	2	13	12			
											%																	
								Carnegie			No.	Pennsylvania Lines West						N.W. System										
1901 1907	22228	0.40-0.55 0.45-0.60	over 0.07 0.07	1.20				51500	61800		%	2 5/10	7	5		15	15	13	25			2 5/10	15			40	23.3	18 0
											No.	1	3	2		6	6	5	10			1	6	15	25			
											%																	
								Cambria			No.	Pennsylvania Lines West						N.W. System										
1903	1549	0.40-0.55 0.45-0.60	over 0.07 0.07 under	1.20				51500	61800		%																0.0	0.0
											No.																	
											%																	
								Carnegie			No.	Pennsylvania Lines West						S. W. System										
1902 1909	17576	0.40-0.55 0.45-0.60	over 0.07 0.07 under	1.20				58800	61600		%	6	6			4	18	18	46		2					50	33.9	22.1
											No.	3	3			2	9	9	23		1			14	36			
											%																	
								Illinois			No.	Rock Island Lines																
1907	825	0.50- 0.58	.097	0.86	.104			53000	53550		%					33		67								6		72.7
											No.					2		4						6				

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with ~~same~~ same period of previous year.

Record for period of ~~one year~~ 6 months ending October 31 1909 4

o. 100 lb P.S. Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
								Cambria			%																	
											No.		Pennsylvania Railroad Lines East															
1908 1909	10486	0.50	0.08	1.00	0.13			65000	61700		%	4	4		11	4	23	27	23	4								
											No.	1	1		3	1	6	7	6	1				10	16	26		24.8
								Maryland			%																	
											No.		Pennsylvania Lines West N.W. System.															
1908	500	0.50	0.10	1.00	0.12			51500	61800		%																	
											No.															0.0		0.0
								Cambria			%																	
											No.		Pennsylvania Lines West N.W. System															
1908	500	0.50	0.10	1.00	0.12			51500	61800		%																	
											No.															0.0		0.0
								Carnegie			%																	
											No		Pennsylvania Lines West N.W. System															
1909	9483	0.50	0.10	1.00	0.12			51500	61800		%																	
											No.													4	1	5		5.3
								Cambria			%																	
											No.		Pennsylvania Lines West N.W. System															
1909	526	0.50	0.10	1.00	0.12			51500	61800		%																	
											No.															0.0		0.0
								Illinois			%																	
											No.		Pennsylvania Lines West N.W. System															
1909	3275	0.50	0.10	1.00	0.12			51500	61800		%																	
											No.															0.0		0.0
								Carnegie			%																	
											No		Pennsylvania Lines West S.W. System															
1909	6452	0.50	0.10	1.00	0.12			58800	61600		%																	
											No.						3								3	3		4.7
								Cambria			%																	
											No.		Pennsylvania Lines West S.W. System.															
1908 1909	481	0.50	0.10	1.00	0.12			58800	61600		%																	
											No.															0.0		0.0
								Maryland			%																	
											No.		Pennsylvania Lines West S. W. System															
1908	492	0.50	0.10	1.00	0.12			58800	61600		%																	
											No.															0.0		0.0
1909	17½	Bessemer "Special"						Carnegie			%																	
											No.		Pennsylvania Lines West S. W. System															
Totals		0.50	0.10	1.00	0.12			58800	61600																			

shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 months ending Oct. 31st. 1909 5

100 lb. Various Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail. Millions		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
		N.	Y. N.	H. &	H.	Sec		Lackawanna		Scranton	%		New	York	New	Haven	and	Hartford										
											No.																	
1901 1902	7849	0.60 0.70	0.07	0.80 1.05	0.20	0.06		45000	52500		%																	
											No.					2		1						3		3		3.8
								Maryland			%																	
											No.		New	York	New	Haven	and	Hartford										
1907 1908	7882	0.60 0.70	0.07	0.80 1.05	0.20	0.06		45000	52500		%																	
											No.		1						2						3	3		3.8
											%																	
											No.																	
		A.	R.A.	"A"	Sec			Carnegie			%																	
											No.		Pennsylvania			Lines	West	N.	W. System									
1909	1643	0.50	0.10	1.00	0.12			51500	61800		%																	
											No.											1		1		1		6.1
								Carnegie			%																	
											No.		Pennsylvania			Lines	West		S. W. System									
1909	1535	0.50	0.10	1.00	0.12			58800	61600		%																	
											No.								1						1	1		6.5
											%																	
											No.																	
		A.	R.A	"B	Sec			Maryland			%																	
											No.		Baltimore		and	Ohio												
1909	13900	0.46 0.56	0.10	0.80 1.20	0.05 0.20			40000	49000		%					14	44		14		14	14						
											No.					1	3		1		1	1		2	5	7		5.0
								Carnegie			%																	
											No		Pittsburgh		and	Lake	Erie		P.& L.E. Div									
1908	566	0.45 0.55	0.10	0.84 1.14	0.20			42500	57000		%																	
											No.								2						2	2		35.3

_ _ _ _ _ _ _ _ _ _ _ _As shown below_ _ _ _ Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

100 lb. Dudley Section Bessemer Steel. Rolled by Various Steel Co. Record for period of ~~one year~~ 6 months ending October 31, 1909 6

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis C.	P.	Mn.	Si.	S.		Maximum Axle Load of Locomotives. Freight	Passenger	Approximate Gross Tons over Rail. Millions		Kind of Failure: Broken Tang.	Broken Curve	Flow of Metal Tang.	Flow of Metal Curve	Crushed Head Tang.	Crushed Head Curve	Split Head Tang.	Split Head Curve	Split Web Tang.	Split Web Curve	Broken Base Tang.	Broken Base Curve	Total Tang.	Total Curve	Grand Total	Failures per 10,000 tons of New Rail laid Last Year	Present Year
		Dudley		Sec.	N.Y.C.	Type		Lackawanna		Buffalo.	%																	
											No.		Boston and Albany															
1904 1909	29230	0.55	0.10	0.90 1.10	0.13 0.20	0.075 0.08		54200	52500	5.74	%	4	4		24	2	20	6	26	4	4	4	2			50		17.1
											No.	2	2		12	1	10	3	13	2	2	2	1	10	40			
											%																	
											No.																	
		Dudley		Sec.				Lackawanna			%																	
											No.		New	York	Central &	Hudson		River	-Main	Line	- N.Y.	to	Buffalo					
1901 1908	107350	0.50-0.56 0.45-0.55	0.10	0.85 1.05	0.10 0.13			27.1 Tons	29.8 Tons		%	19	10	1½		3½	5	30	13	1½	2½	7	7			116		10.8
											No.	22	12	2		4	6	34	15	2	3	8	8	72	44			
		Dudley		Sec				Carnegie			%																	
											No.		New	York	Central &	Hudson		River	-Main	Line	-N.Y.	to	Buffalo					
1902 1904	13257	0.45 0.55	0.10	0.80 1.20	0.15 0.20	0.069		27.1 Tons	29.8 Tons		%	18	9	9				28	9	18			9			11		8.3
											No.	2	1	1				3	1	2			1	8	3			

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

100 lb. Various Section Open Hearth Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909. 1

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail. Millions			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail Laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
													Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve			
		A.S.C.E. Sec.						Dominion Iron & Steel Co				% No.		Grand Trunk															
1907	34382	055 065	065	080 110	020	069		49532	48120			% No.	5 1				5 1		42 8		27 5		21 4		19		19	6.4	[illegible]
		A.S.C.E. Sec						Algoma				% No.		Michigan Central															
1907 1909	3811	0.6[illegible] 0.65	0.031 0.016	0.91 0.70	0.0[illegible] 0.0[illegible]	0.050 0.044		44000	47000	2.00		% No.																	
		A.S.C.E. Sec						Bethlehem				% No.		Lehigh & Hudson River															
1909	460	0.65 0.80	0.04	0.70 1.00	0.20			42500	47500			% No.																	
		N.Y.N.H.&H. Sec						Bethlehem				% No.		New York, New Haven & Hartford															
1909	4300	0.70 0.79	.02 .03	0.[illegible] 0.90	[illegible]	[illegible]		45000	5[illegible]			% No.	14								43 3	27 2	14 1		[illegible]	[illegible]	7		.93
		Dudley Sec						Lackawanna				% No.		New York Central & Hudson River [illegible]															
1908	2274	.60 .70	.03	[illegible]	[illegible]	.04		21[illegible]	2[illegible]			% No.																	
												% No.																	
		Dudley Sec Bessemer (Ferro Titanium) Lackawanna Buffalo										% No.		Boston and Albany															
1909	7940	.48	.0[illegible]	1.00	.13	.06	.0[illegible]	54200	52500	5.74		% No.		1												1	1		13
												% No.																	
												% No.																	
		95 lb B & A Sec Bessemer Bethlehem										% No.		Boston and Albany															
1891 1892	16000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		54200	5[illegible] 500	9.57		% No.	[illegible]				[illegible] 2	[illegible]	[illegible]	[illegible]		[illegible]			[illegible]	.33	54		[illegible]
		95 lb B & A Sec Bessemer Lackawanna Scranton										% No.		Boston and Albany															
1893 1894	47670	.60	.0[illegible]	1.20 ~~0.96~~	.15	.0[illegible]		54200	5[illegible]	9.57		% No.	[illegible]	[illegible]			[illegible]	[illegible]				[illegible]	8 3		.75	.5	40	27	8.4
Totals																													

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

100 lb. P.S. Section Open Hearth Steel. Rolled by Various Steel Co.

Record for period of 6 months ~~one year~~ ending October 31 1909

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Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail. Millions		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
								Cambria			%																	
											No		Pennsylvania Railroad Lines East															
1909	1352	085	.012	065	041			65000	61700		%																	
											No.							1						1		1		7.4
		Open Hearth "A"						Carnegie			%																	
											No.		Pennsylvania Lines West N W System															
1909	2512	0 70 0 83	0.03	0 80	0 05 0.20			51500	61800		%																	
											No.							1						1		1		4.0
		Open Hearth "A"						Illinois			%																	
											No.		Pennsylvania Lines West N W System															
1909	2305	0.70 0 83	0.03	0 80	0 05 0 20			51500	61800		%	50		12½		25		12½										
											No	4		1		2		1						8		8		34.7
		Open Hearth "A"						Carnegie			%																	
											No.		Pennsylvania Lines West S W. System															
1909	2522	0 70 0 83	003	0.80	0.05 0.20			58800	61600		%																	
											No.																	
		Open Hearth "A Special"							Carnegie		%																	
											No.		Pennsylvania Lines West S.W. System															
1909	4½	0.70 0.83	0.03	0 80	0.05 0.20			58800	61600		%																	
											No.																	
		Open Hearth "B"						Carnegie			%																	
											No.		Pennsylvania Lines West N. W. System															
1909	991	0.62 0.75	0 04	0 80	0.05 0 20			51500	61800		%																	
											No.																	
		Open Hearth "B"						Carnegie			%																	
											No		Pennsylvania Lines West N.W System															
1909	526	0 62 0.75	0 04	0.80	0 05 0.20			51500	61800		%																	
											No					1								1		1		190
		Open Hearth "B"						Carnegie			%																	
											No		Pennsylvania Lines West S W. System															
1909	1054	0 62 0 75	0.04	0 80	0.05 0.20			58800	61600		%																	
											No.																	

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year

90 lb. ASCE Section Bessemer Steel. Rolled by Various Steel Co

Record for period of 6months ~~one year~~ ending Oct. 31 1909 9

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail Millions		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		C	P.	Mn.	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
												Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang	Curve	Tang	Curve			
								Lackawanna			%																	
											No		Buffalo Rochester & Pittsburgh															
1905 1907	10000	0.48 0.50	0.0	0.80 1.0	0.20			41000	53000		%				36	9			18			[illegible]	28					
											No				4	1			2			1	3	2	9	11		11.0
								Cambria			%																	
											No		Central Railroad of New Jersey															
1907	2204	[illegible] 0.58	0.0	[illegible] 1.00	0.20			54000	58000		%	6	12					12	58		12							
											No	1	2					2	10		2			3	14	17	86.2	77.1
								Maryland			%																	
											No		Central Railroad of New Jersey															
1908 1909	28836	0.45 0.65	0.08 0.0	0.90 1.15	0.10 0.20	under 0.08	[illegible] under 6	54000	58000		%	18	9	4	2	14	9	24	2	16	2							
											No	10	5	2	1	8	5	13	1	9	1			42	13	55		19.1
								Carnegie			%																	
											No		Central Railroad of New Jersey															
1906	3210	0.54 0.64	0.0	1.05 1.30	0.20			54000	58000		%		40			20		20	20									
											No		2			1		1	1					2	3	5	2.2	15.6
								Lackawanna			%																	
											No		Central Railroad of New Jersey															
1904 1907	18835	0.54 0.65	0.08 0.0	[illegible] [illegible]	0.10 0.20			54000	58000		%	12	12			24	15	5	22	2½	2½	5						
											No	5	5			10	6	2	9	1	1	2		20	21	41		21.8
								Illinois			%																	
											No.		Chicago & North Western															
1898 1909	174301										%	59	7½			14	1	3	4	7½		4						
											No.	62	8			15	1	3	4	8		4		92	13	105		6.0
								Lackawanna			%																	
											No		Cleveland Cincinnati Chicago & St. Louis															
1906	5250	0.50 0.60	0.10	0.80 1.0	0.20			52000	53000	15.13	%			6	3	38	25	13	6			3	6					
											No			2	1	12	8	4	2			1	2	19	13	32	19.3	61.0
								Illinois			%																	
											No		Cleveland Cincinnati Chicago & St. Louis															
1906 1909	56,708	0.44 0.54	0.10	0.90 1.10	0.13 0.20	.075		52000	53000	1.375	%	15¼	3	1	1	25¼	12¼	27¼	7			6	2					
											No	15	3	1	1	25	12	27	7			6	2	74	25	99	11.5	17.4
								Carnegie			%																	
											No		Cleveland, Cincinnati Chicago & St. Louis															
1905 1909	27028	0.50 0.60	0.10	0.80 1.10	0.20			52000	53000	1.375	%	7½	4			40	1	37½	2½			7½						
											No	6	3			32	1	30	2			6		74	6	80	199	29.6
											%																	
											No																	
Totals																												

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

90 lb. ASCE Section Bessemer Steel. Rolled by Various Steel Co.

Record for period of 6 months ~~one year~~ ending Oct. 31 1909 10

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
								Bethlehem &	Lackawanna			%																	
												No.		Delaware Lackawanna & Western															
1905 1908	41026											%	23	35		4	4	4		11		11	4	4			26		6.3
												No	6	9		1	1	1		3		3	1	1	8	18			
								Carnegie				%																	
												No.		Hocking Valley															
1907	5610							41000	46000			%					50	17	33								6		107
												No.					3	1	2						5	1			
								Maryland				%																	
												No.		Philadelphia & Reading															
1902 1909	126711	0.45 0.64	0.10	0.80 1.20	0.20			54833	55150			%	3	4	19	36 4/10	9 5/10	17 3/10	3	3	1	1		2 6/10			346		27.3
												No.	11	13	66	126	33	60	12	11	2	3		9	124	222			
								Carnegie				%																	
												No.		Philadelphia & Reading															
1905	6852	0.54 0.64	0.10	0.90 1.15	0.20			54833	55150			%	12 5/10	25			12 5/10		37 5/10			12 5/10					8		11.7
												No.	1	2			1		3			1			5	3			
								Cambria				%																	
												No.		Philadelphia & Reading															
1905	3450	0.54 0.64	0.10	0.90 1.15	0.20			54833	55150			%		17		17			66								6		17.4
												No.		1		1			4						4	2			
								Lackawanna				%																	
												No.		Philadelphia & Reading															
1905 1906	5669	0.54 0.64	0.10	0.90 1.15	0.20			54833	55150			%				36	13	13	25	13							8		14.1
												No.				3	1	1	2	1					3	5			
								Pennsylvania				%																	
												No.		Philadelphia & Reading															
1901 1902	17167	0.53 0.63	0.10	0.80 1.20	0.20			54833	55150			%															3		1.7
												No.	3												3	0			
								Carnegie				%																	
												No.		Pittsburgh & Lake Erie						P. & L. E. Division									
1900 1908	32040	0.43 0.53	0.10	0.80 1.10	0.20			42500	57000			%		5					44	38	8	5					79		24.7
												No.		4					35	30	6	4			41	38			
								Carnegie				%																	
												No.		Pittsburgh & Lake Erie						P. McK. & Y. Division									
1903 1908	3326	0.45 0.55	0.10	0.80 1.10	0.20			42000	52000			%	2[illegible]	13				5¼	26	42		11					38		114.3
												No.	1	6				2	10	16		4			11	27			

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

90 lb. Various Section. Bessemer Steel. Rolled by Various Steel Co. Record for period of ~~one year~~ 6 months ending Oct. 31 1909 11

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve		Last Year	Present Year
		A.R.A.		"A" Sec.				Illinois South Works			%																	
											No.		Baltimore & Ohio															
1908 1909	5100	0.45 0.55	0.10	0.80 1.20	0.05 0.20			23237	25083		%	20				60		20										
											No.	1				3		1						5		5		9.8
		A.R.A.		"B" Sec				Carnegie			%																	
											No.		Baltimore & Ohio Southwestern															
1908 1909	6000	0.45 0.55	0.10	0.80 1.20	0.05 0.20			46475	54750	2.74	%		4		4		75	5	8	4								
											No.		1		1		18	1	2	1				2	22	24		40.0
		A.R.A.		"B" Sec.				Carnegie			%																	
											No.		Baltimore & Ohio Railroad															
1909	8400	0.45 0.55	0.10	0.80 1.20	0.05 0.20			23237	25085		%																	
											No.					1	1							1	1	2		2.4
		A.R.A.		"B" Sec.				Maryland			%																	
											No		Baltimore & Ohio															
1909	7050	0.45 0.55	0.10	0.80 1.20	0.05 0.20			23237	25085		%																	
											No.								3						3	3		4.3
		A.R.A.		"B" Sec.				Cambria			%																	
											No.		Baltimore & Ohio															
1909	5000	0.45 0.55	0.10	0.80 1.20	0.05 0.20			23237	25085		%	6	6		6	40	12		24		6							
											No.	1	1		1	7	2		4		1			8	9	17		34.0
		A.R.A.		"B" Sec.				Illinois South Works			%																	
											No.		Baltimore & Ohio															
1909	2000	0.45 0.55	0.10	0.80 1.20	0.05 0.20						%																	
											No.																	
		~~Dudley &~~ A.S.C.E. Sec						Carnegie			%																	
											No		Buffalo Rochester & Pittsburgh															
1902 1907	21800	0.48 0.50	0.10	0.80 1.10	0.20			41000	53000		%	8		8	17	17	21	17	8				4					
											No	2		2	4	4	5	4	2				1	12	12	24		11.0
		Great Northern Sec.						Illinois			%																	
											No.		Great Northern															
1908	11131	0.43 0.53	0.10	0.80 1.10	0.20						%							67	33									
											No.							2	1					2	1	3	1.1	2.7
		Great Northern Sec.						Cambria			%																	
											No.		Great Northern															
1908	9693	0.43 0.53	0.10	0.80 1.10	0.20						%		20				20		60									
											No.		1				1		3						5	5	5.6	5.2

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909 12

90 lb. Various Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail Laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
	Great Northern Sec.							Maryland				%																	
												No.		Great Northern															
1908	4887											%																	
												No.					1			2					1	2	3		6.1
	Great Northern Sec.							Lackawanna				%																	
												No.		Great Northern															
1908	14818	0.43 0.53	0.10	0.80 1.10	0.20							%																	
												No.																1.3	
	Common Standard				Harriman Lines Sec.				Maryland			%																	
												No.		Galveston Harrisburgh & San Antonia															
1906 1907	5003	0.60	0.085	0.90	0.20	.075		51266	53330			%																	
												No.								1		1				2	2		4.0
	C. S. Sec.							Carnegie				%																	
												No		Galveston Harrisburg & San Antonia															
1908	2249	0.60	0.085	0.90	0.20	.075		42000	46000			%																	
												No.							1						1		1		4.5
	C. S. Sec.							Not Stated				%																	
												No.		Texas and New Orleans															
1907	296	0.60	.085	0.30	0.20	.075		42000	46000			%																	
												No.								1						1	1		33.8
	C.S. Sec							Illinois				%																	
												No.		Oregon Short Line															
1905	2598	0.50 0.60	0.10	0.80 1.10	0.20	.075		$24\frac{35}{100}$	26½ Tons			%	17						50	33									
												No.	1						3	2					4	2	6	15.4	23.1
	C.S. Sec.							Colorado Fuel & Iron Co.				%																	
												No.		Union Pacific															
1907	10464							24 Tons	28 Tons			%							33		67								
												No.							1		2				3		3	4.8	2.9
	C.S. Sec.							Lorain				%																	
												No.		Union Pacific															
1906	2324	0.50 0.60	0.10	0.80 1.10	0.20	.075		24 Tons	28 Tons			%																	
												No.								2						2	2	10.8	8.6
	C.S. Sec.							Carnegie				%																	
												No.		Union Pacific															
1906 1907	36897	0.60 0.60	0.10	0.80 1.10	0.20	.075		24 Tons	28 Tons			%	5½	4½			8	1	42	30	7		2						
												No.	5	4			7	1	37	26	6		2		57	31	88	15.1	23.7

---------- As shown below ---- Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with same period of previous year.

Record for period of ~~one year~~ ending --- Oct 31 -- 1909 13

90 lb. Various Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail. Millions				Kind of Failure														Grand Total	Failures per [illegible] Tons of New Rail Laid	
														Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn	Si	S.		Freight	Passenger					Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
	Common Standard Sec. Harriman Lines							Illinois					%																	
													No	Union Pacific																
1906 1907	37494	0.50 0.60	0 10	0.80 1.10	0.20	.075		24 Tons	28 Tons				%	18½				4½		41	18½	13		4½						
													No	4				1		9	4	3		1		18	4	22	2 0	59
	C. S. Sec.							Illinois					%																	
													No	Illinois Central																
1908	2473	0.45 0 55	0 10	0 04 1.4	020	075		48500	40000	110.0			%																	
													No		1		1		1		5		1				9	9		36 4
													%																	
													No																	
													%																	
													No																	
90	lb. Various Sections Open Hearth Steel. Rolled by various Steel Co's.												%																	
													No																	
	A.S.C.E. Sec.							Bethlehem					%																	
													No	Buffalo Rochester & Pittsburg																
1908	1500	0.50 0 72	0 04	0 60 0 90	0 20			41000	53000				%																	
													No				1			1						1	1	2		13.3
	A S C E Sec					Open Hearth.		Bethlehem					%																	
													No	Central Railroad of New Jersey																
1908 1909	6161	0.57	031	0.82		.044		54000	58000				%	12	27	2½		15	2½	8	8	15	2½	5	2½					
													No	5	11	1		6	1	4	4	5	1	2	1	23	8	41		66 5
	A.R.A. "A" Sec.							Illinois Gary					%																	
													No	Baltimore and Ohio																
1909	2000	0 65 0.80	0 04	0 75 1.00	0.05 0.20			23237	25083				%																	
													No																	
	A.R.A. "A" Sec							Illinois					%																	
													No	Chicago Burlington & Quincy																
1909	43700	0.48 0.58	0.10	0.80 1.10	0.20								%	2		6	4	11	9	49	13	6								
													No	1		3	2	5	4	23	6	3				35	12	47		7.6
	A.R.A. "A" Sec.							Colorado Fuel & Iron					%																	
													No	Chicago Burlington & Quincy																
1909	21000	0.48 0.58	0.10	0 80 1.10	0.20								%																	
													No									1				1		1		0 5
	A.R.A. "B" Sec							Bethlehem					%																	
													No	Baltimore & Ohio																
1908 1909	7600	0.65 0.80	0.04	0.75 1.00	0.05 0.20			23237	25085	7¾			%	4	10 5/10	2		4	29	2	36	2	.05							
													No	2	5	1		2	14	1	17	1	5			7	41	48		63.2
Totals																														

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

90 lb. Various Section. Open Hearth Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909 14

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross* Tons over Rail.		Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
											%																	
		A.R.A. "B" Sec.						Illinois Gary			No.		Baltimore & Ohio															
1909	1000	0.65 0.80	0.04	0.75 1.00	0.05 0.20						%																	
											No.																	
											%																	
		A.R.A. "B" Sec						Illinois			No.		Northern Pacific															
1909	23615	0.62 0.75	004	0.80	0.05 0.20						%	33		33				34										
											No.	1		1				1						3		3		1.3
											%																	
											No.																	
											%																	
		D.L.&W. Sec.						Bethlehem			No.		Delaware Lackawanna & Western															
1908 1909	21778										%	22	46					8	3-	3	15	3						
											No	9	18					3	1	1	6	1		14	25	39		17.9
											%																	
		D.L.&W. Sec.						Lackawanna			No.		Delaware Lackawanna & Western															
1909	5044										%																	
											No.		1												1	1		2.0
											%																	
											No.																	
											%																	
		Great Northern Sec						Pennsylvania			No.		Great Northern															
1903 1909	7790	0.59 0.78	0.04	0.60 0.90	0.06 0.20						%																	
											No.																	
											%																	
		Great Northern Sec.						Bethlehem			No		Great Northern															
1908 1909	7907	0.54 0.80	0.04 0.06	0.60 1.00	0.20						%			7		33	13	20	7	13			7					
											No			1		5	2	3	1	2			1	11	4	15	3.8	19.0
											%																	
		Great Northern Sec						Illinois			No.		Great Northern															
1909	16944	0.59 0.75	0.04	0.60 1.00	0.20						%																	
											No.									1				1		1		0.6
											%																	
											No.																	
											%																	
		Common Standard Harriman Lines Sec.								Tennessee Coal	No.		Illinois Central															
1909	2473									& Iron	%																	
											No.						1		1	1		1		2	2	4		16.2

As shown below Railroad

Summary of Steel Rail Failures for [illegible] compared with same period of previous year.

90 lb. Various Section Various Steel Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909 15

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail. Millions				Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
														Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si	S.		Freight	Passenger					Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
	Common Standard Harriman Lines Sec Tennessee Coal Iron & R.R.Co. Open Hearth												%		Galveston Harrisburgh & San Antonio															
													No.																	
1909	3202	0.60	0.85	0.90	0.20	.075		51266	53330	2.00			%						25		75									
													No.						1		3						4	4		12.5
	C S Sec Open Hearth. Tennessee Coal Iron and R.R. Co.												%																	
													No.		Southern Pacific															
1908	3317	0.55 0.65	0.85	0.75 1.10	0.20	.075		51700	58400				%	30						10	40	10	10							
													No.	3						1	4	1	1			5	5	10		
													%																	
													No.																	
	A S C E. Sec Chrome Nickel												%																	
													No.		Central Railroad of New Jersey															
1909	5014							54000	58000				%	8	38 3/10				9/10	7 7/10	44 3/10	3/10	5/10							
													No.	28	134				3	27	155	1	2			56	294	350		698
													%																	
													No.																	
	Great Northern Sec. Special High Carbon Pennsylvania												%																	
													No.		Great Northern															
1908	25	0.34 0.93	0.02	0.73 0.81	0.04								%																	
													No.																	
													%																	
													No.																	
													%																	
													No.																	
													%																	
													No.																	
													%																	
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													No.																	
													%																	
													No.																	
													%																	
													No.																	
													%																	
													No.																	
													%																	
													No.																	
Total																														

As shown below Railroad

Summary of Steel Rail Failures for One Year compared with same period of previous year.

85 lb. PRR Section Bessemer Steel. Rolled by Various Steel Co. Record for period of 6 months one year ending Oct. 31 1909 16

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve		Last Year	Present Year
								Cambria			%																	
											No.		Baltimore Chesapeake and Atlantic															
1906		0.51	.095	0 89	.053	.058					%																	
1909	674	0.56	.099	0.98	.078	.086		48 Tons	48 Tons		No.																	
								Maryland			%																	
											No.		Cumberland Valley															
1899											%	14	14				29	15		14		14						
1902	5008							46000	50400		No.	1	1				2	1		1		1		4	3	7	14.0	14.0
								Cambria			%																	
											No.		Pennsylvania R.R. Lines East															
1908											%		20						60			20						
1909	1343	0.50	0.08	1.00	0.13			58300	61500		No.		1						3			1		1	4	5		37.2
								Carnegie			%																	
											No.		Pennsylvania R.R. Lines East															
1908											%	18	18			9	27½		27½									
1909	4068	0.50	0.08	1.00	0.12			58300	61500		No.	2	2			1	3		3					3	8	11		27.0
								Lackawanna			%																	
											No.		Pennsylvania R.R. Lines East															
1908											%																	
1909	1581	0.50	0.08	1.00	0.12			58300	61500		No.							1					1	1	1	2		12.7
								Maryland			%																	
											No.		Pennsylvania R.R. Lines East															
											%																	
1908	1631	0.50	0.08	1.00	0.12			47800	48100		No.	1												1		1		6.1
								Carnegie			%																	
											No.		Pennsylvania Lines West						N.W. System									
1892											%	20				22		23	17	13		5						
1898	55370							51500	61800		No.	9				10		11	8	6		2		38	8	46	8.1	8.3
								Illinois			%																	
											No.		Pennsylvania Lines West						N.W. System									
1892											%	40				40		20										
1898	21060							51500	61800		No.	2				2		1						5		5	1.4	2.4
								Cambria			%																	
											No.		Pennsylvania Lines West						N.W. System									
1892											%																	
1897	4875							51500	61800		No.																	

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

85 lb. Various Section Bessemer Steel. Rolled by Various Steel Co.

Record for period of 6 months ~~one year~~ ending Oct. 31 1909

17

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail. Millions		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si	S.		Freight	Passenger			Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
		P.R.R. Sec.						Carnegie			%																	
											No.		Pennsylvania Lines West S W System															
1895 1898	20386							58800	61600		%					12		76	12							17	20.6	8.3
											No					2		13	2					15	2			
		P.R.R. Sec						Illinois			%																	
											No.		Pennsylvania Lines West S. W. System															
1895 1898	8264							58800	61600		%																2.4	
											No																	
		P.R.R. Sec						Cambria			%																	
											No		Pennsylvania Lines West S W System															
1897	108							58800	61600		%																	
											No																	
											%																	
											No																	
											%																	
		A.S.C.E. Sec						Colorado Fuel & Iron			No.		Atchison Topeka & Santa Fe - Albuquerque Div															
1903 1906	14816							50633	54850		%	14	14					38	29	5						.21	12.1	14.2
											No.	3	3					8	6	1				12	9			
		A.S.C.E. Sec.						Lackawanna			%																	
											No.		Atchison Topeka & Santa Fe - Albuquerque Div.															
1904	3596							50633	54850		%		8			8	34	8	17	17			8			12	21.5	33.4
											No.		1			1	4	1	2	2			1	4	8			
		A.S.C.E. Sec.						Colorado Fuel & Iron			%																	
											No.		Atchison Topeka & Santa Fe - Arizona Div.															
1908 1909	402							53960	52900		%	27	6	9	2	27	10	16	2			1				90		
											No	24	5	8	2	24	9	15	2			1		72	18			
		A. S. C. E. ~~Sec~~						Illinois			%																	
											No		Atchison Topeka & Santa Fe - Illinois Div.															
1909	695							82 Tons	101 Tons	4.12	%	6	10	10		32	13	10		16	3					31		
											No	2	3	3		10	4	3		5	1			23	8			
		A. S. C. E. Sec.						Colorado Fuel & Iron Co.			%																	
											No.		Atchison Topeka & Santa Fe - Los Angeles Div.															
1903 1909	14784										%			14	14				14	29		29				7		4.7
											No			1	1				1	2		2		5	2			
		A. S. C. E. Sec.						Illinois		3.94	%																	
											No.		Atchison Topeka & Santa Fe - Missouri Div.															
1909	14367							88 Tons	50 Tons		%	19	17	3		19	14			8		17	3			36		25.1
											No	7	6	1		7	5			3		6	1	24	12			

As shown below Railroad

Summary of Steel Rail Failures for One Year compared with same period of previous year.

85 lb. A.S.C.E. Section Bessemer Steel. Rolled by Various Steel Co. Record for period of 6 months one year ending Oct. 31 1909 18

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
											%																	
								Maryland			No.		Atchison Topeka & Santa Fe - Missouri Div.															
1909	7530							88 Tons	50 Tons		%																	
											No.									1	1			1	1	2		.2.7
											%																	
								Lackawanna			No.		Atlantic Coast Line															
1907	10000	0.45 0.58	0.10	0.80 1.10	0.20						%																	
											No.						1								1	1		1.0
											%																	
								Maryland			No.		Atlantic Coast Line															
1906 1907	22720	0.48 0.58	0.10	0.80 1.10	0.20						%	20				20		20	20	20								
											No.	1				1		1	1	1				4	1	5		2.2
											%																	
								Pennsylvania			No.		Atlantic Coast Line															
1906 1907	36800	0.48 0.58	0.10	0.80 1.10	0.20						%	33				16				17		34						
											No.	2				1				1		2		6		6		1.6
											%																	
								Carnegie			No.		Baltimore & Ohio															
1899 1908	193607	0.47 0.60	.082 0.10	0.80 1.10	0.20	.044 .053		29542	27375		%	2	3/10	4	1 7/10	32	25	11	15	5	3	5/10	5/10					
											No.	9	1	14	6	128	95	41	57	19	12	2	2	213	173	386	29.4	19.9
											%																	
								Maryland			No.		Baltimore & Ohio															
1899 1908	84452	0.45 0.55	.068 0.10	0.80 1.20	0.05 0.20	.055 .078		23237	25085		%	1 4/10	11	1 4/10		20	29	9	17	3	5 6/10		3					
											No.	1	9	1		14	20	6	12	2	4		2	24	47	71		8.4
											%																	
								Cambria			No.		Baltimore & Ohio															
1899 1908	71370	0.45 0.55	.080 .104	.0.85 1.15	0.06 0.20	.066 .076		23237	25085		%	6	4		19	19	31	5	10	4	2							
											No.	6	4		20	19	32	5	10	4	2			34	68	102	47.9	14.3
											%																	
								Illinois S. Works			No.		Baltimore & Ohio.															
1901 1908	18082	0.47 0.50	.004 .098	0.85 1.00	.099 .101			23237	25085		%	36				9		55										
											No.	4				1		6						11		11	4.9	6.1
											%																	
								Carnegie			No.		Baltimore and Ohio Southwestern															
1898 1909	88447							46475	54750		%	2	4/10	2/10	6/10	36	26	22	9	2	1 8/10							
											No.	10	2	1	3	189	137	114	47	10	9			324	198	522		59.0

-----------As shown below---- Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

85 lb. A.S.C.E. Section Bessemer Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ ending October 31 1909 19

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
								Cambria			%																	
											No.		Baltimore & Ohio Southwestern															
1900	4457							46475	54750		%	7				14	36	22	7	14								
1906											No.	1				2	5	3	1	2				8	6	14		31.4
								Illinois			%																	
											No.		Baltimore & Ohio Southwestern															
1901	575							38780	45750		%																	
											No.																	
								Maryland			%																	
											No.		Bangor & Aroostook															
1907	14362	0.48	0.10	0.80	0.20			44000	43000		%																	
1908		0.58		1.10							No.												1		1	1		0.7
								Lackawanna		Buffalo	%																	
											No.		Boston & Maine															
1904	34239	0.43	0.10	0.80	0.20			33600	32720		%	28	4		3	3	10	10	19	5	1	5	12					
1908		0.53		1.10							No.	22	3		2	2	8	8	15	4	1	4	9	40	38	78		22.7
								Lackawanna		Scranton	%																	
											No.		Boston & Maine															
1898	17713	0.43	0.10	0.80	0.20			33600	31300		%	22½	5	7½		10	7½	10	2½		2½	25	7½					
1901		0.53		1.10							No.	9	2	3		4	3	4	1		1	10	3	30	10	40		22.6
								Maryland			%																	
											No.		Boston & Maine															
1902	2631	0.43	0.10	0.80	0.20			33600	31300		%		33								67							
		0.53		1.10							No.		1								2				3	3		11.4
								Carnegie			%																	
											No.		Boston & Maine															
1899	1786	0.43	0.10	0.80	0.20			31100	31100		%		67					33										
		0.53		1.10							No.		2					1						1	2	3		16.8
								Cambria			%																	
											No.		Chesapeake & Ohio															
1905	16837							51000	48000		%																	
1906											No.	1					1							1	1	2		1.2
								Carnegie			%																	
											No.		Chesapeake & Ohio															
1906	29380							51000	48000		%	20	10			50	10	10										
1907											No.	2	1			5	1	1						8	2	10		3.4
											%																	
											No.																	
Totals																												

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

85 lb. A.S.C.E Section Bessemer Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending October 31 1909 20

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
												Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve			
								Maryland			%																	
											No.		Chesapeake & Ohio															
1908	5254							51000	48000		%															1		1.9
											No.			1										1				
								Carnegie			%																	
											No.		Chicago and Eastern Illinois															
1905 1908	11595	0.51	.095	0.95	.084	.039		47300	51750		%	3½				30		63	3½							30		25.9
											No.	1				9		19	1					29	1			
								Illinois			%																	
											No.		Chicago and Eastern Illinois															
1899 1905	13517	0.42 0.53	0.10	1.00 1.10	0.20			47300	51500		%	36						27	18½	18½						11		8.1
											No	4						3	2	2				9	2			
								Carnegie			%																	
											No.		Evansville and Terre Haute															
1904 1907	4305										%	25					50				25					4		9.3
											No	1					2				1			1	3			
								Maryland			%																	
											No.		Evansville and Terre Haute															
1907	400										%																	
											No.																	
								Colorado Fuel & Iron			%																	
											No.		Fort Worth and Denver City															
1909	11535							185000	187700	Co.	%															1		0.9
											No.									1				1				
								Cambria			%																	
											No		Grand Rapids and Indiana															
1903 1907	10670	0.40 0.55	0.10	1.20				49000	44000		%	17	8				6		3			30	36			36	16.9	33.8
											No.	6	3				2		1			11	13	17	19			
								Cambria			%																	
											No.		Grand Rapids & Indiana (Cin. Rich. & Ft. Wayne R.R.															
1903	930	0.40 0.55	0.10	1.20							%															1		10.8
											No							1						1				
								Illinois			%																	
											No		Illinois Central															
1898 1908	310155	0.43 0.53	0.10	0.80 1.10	0.20	.075		48500	46000		%	38	10	5	3	4	6	18	7	7	1	1				82	2.6	2.6
											No.	31	8	4	2	3	5	15	6	6	1	1		60	22			

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with same period of previous year.

85 lb. ASCE Section. Bessemer Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909

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Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail. *Millions*		Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
											%																	
								Carnegie			No.		Illinois Central															
1901 1905	6970	0.43 0.53	0.10	0.80 1.10	0.20			48500	46000		%							67	33									
											No.							6	3					6	3	9	1.6	12.9
								Cambria			%																	
											No.		Norfolk and Western															
1903 1908	28000	0.50 0.58	0.09 0.10	1.10	0.10 0.12	0.04 0.05		46000	45000	20 to 91	%		20	10		10	10	10	20	20								
											No.		2	1		1	1	1	2	2				5	5	10	9.0	3.6
								Carnegie			%																	
											No.		Norfolk and Western															
1901 1908	86500	0.50 0.58	0.09 0.10	1.10	0.10 0.11	0.04		46000	45000	10 to 115	%	1	9	3	3	9	22	18	33	1		1						
											No.	1	6	2	2	6	15	12	22	1		1		23	45	68	8.6	7.9
								National			%																	
											No.		Norfolk and Western															
1901.	4000	0.52	0.09	0.80	0.15	0.04		44000	45000		%																	
											No.																	
								Maryland			%																	
											No.		Norfolk and Western															
1901 1908	94500	0.50 0.58	0.09 0.10	1.00 1.10	0.09 0.12	0.04 0.06		46000	45000	9 to 65 mil.	%					20	66	7		7								
											No.					3	10	1		1				5	10	15	2.3	1.6
								Illinois			%																	
											No.		Northern Pacific															
1903 1909	153451	0.43 0.58	0.10	0.80 1.10	0.20			54730	52300		%	19	7	$\frac{3}{10}$	4	7	$16\frac{6}{10}$	8	$7\frac{3}{10}$	2	1	19	9					
											No.	59	22	1	12	23	52	26	23	6	4	61	27	176	140	316		20.6
								Lackawanna			%																	
											No		Northern Pacific															
1906 1908	35603	0.43 0.58	0.10	0.80 1.10	0.20			54730	52300		%	$5\frac{1}{2}$	5			2	30	$5\frac{1}{2}$	12			39	1					
											No	6	5			2	31	6	13			41	1	55	50	105		29.5
								Lorain			%																	
											No		Northern Pacific															
1906	4509	0.48 0.58	0.10	0.80 1.10	0.20			51750	52300		%																	
											No.		1												1	1	19.6	2.2
								Carnegie			%																	
											No.		Northern Pacific															
1906 1907	5193	0.48 0.58	0.10	0.80 1.10	0.20			51750	52300		%	80						10					10					
											No.	8						1					1	9	1	10		19.2
											%																	
											No																	
Totals																												

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

85 lb. A.S.C.E. Section Bessemer Steel. Rolled by Various Steel Co. Record for period of ~~one year~~ 6 months ending Oct. 31 1909 22

Lines	Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
			C.	P.	Mn.	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
													Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve			
1			After 1901						Carnegie			%																	
												No.		Pennsylvania Lines West N.W. System															
2	1899 1907	170439	40-.55 45-.60	over 0 07 0 07	1.20				51500	61800		%	18	8	1 4/10	1	20	9	26	9	3 3/10	1 4/10	1	1 9/10					
												No.	39	17	3	2	42	20	55	20	7	3	2	4	148	66	214	16.9	12.6
3			After 1901	under					Illinois			%																	
												No.		Pennsylvania Lines West N.W. System															
4	1899 1904	12246	.40-55 45-60	over 07 07	1.20				51500	61800		%																	
												No.		1					1						1	1	2	1.8	1.6
5			After	under 1901					Cambria			%																	
												No.		Pennsylvania Lines West N.W. System															
6	1900 1906	10677	40 55 45-60	over 0 07 0 07	1.20				51500	61800		%																	
												No.							1	1					1	1	2	8.2	1 9
7				under					National			%																	
												No.		Pennsylvania Lines West N.W. System															
8	1901	14942	0.30 0.50						51500	61800		%	14				15	14	57										
												No.	1				1	1	4						6	1	7	3.3	4.7
9			After 1901						Republic			%																	
												No.		Pennsylvania Lines West N.W. System															
10	1905	4584	0.40 55 .45 .60	over .07 .07	1.20				51500	61800		%																	
												No.					1	1				1			1	2	3	.53	6.5
11				under					Lorain			%																	
												No.		Pennsylvania Lines West N.W. System															
12	1900 1901	8323	.40 55 .45 60	over 0 07 0.07	1.20				51500	61800		%																	
												No.																	
13				under After 1901					Carnegie			%																	
												No		Pennsylvania Lines West S.W. System.															
14	1899 1909	200602	.40-55 .45-60	over 0 07 0 07	1.20				58800	61600		%	12	7	5	1	8	7	44	7	7	1		1					
												No	16	8	6	1	9	8	53	8	8	1		1	92	27	119	11.3	5 9
15				under After 1901					Illinois			%																	
												No		Pennsylvania Lines West. S.W. System.															
16	1899 1906	15322	0.40 55 45-60	over 0.07 0.07	1.20				58800	61600		%	19		25	38			6	6	6								
												No.	3		4	6			1	1	1				9	7	16	10.4	10.4
17				under After 1901					Cambria			%																	
												No.		Pennsylvania Lines West S.W. System.															
18	1900 1906	4922	.40-.55 .45-.60	over 0.07 0.07	1.20				58800	61600		%																	
												No.							1						1		1	2.0	2.0
19				under								%																	
												No																	
Totals																													

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with same period of previous year.

Record for period of ~~one year~~ ending Oct. 31 1909

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85 lb. A.S.C.E. Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure															Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total		Grand Total		
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
								National			%																	
											No.		Pennsylvania Lines West							S.W. System.								
1900	1305							58800	61600		%																	
											No																	
								Carnegie			%																	
											No.		Rock Island Lines															
1905	1402	0.44 0.52	0.90 0.95	0.85 0.95				53300	53550		%																	
											No.																	
								Illinois			%																	
											No.		Rock Island Lines															
1900 1909	135530	0.43 0.63	.088 0.10	0.83 1.10	.080 0.20			53000	53550		%	25	7			14	14	10	18	4	4	4		16	12	28	16.5	2.1
											No	7	2			4	4	3	5	1	1	1						
								Lorain			%																	
											No		Rock Island Lines															
1905 1906	5074	0.48 0.58	0.10	0.80 1.10	0.20			53000	53550		%												1	2	1	3		5.9
											No	2																
								Carnegie			%																	
											No.		St. Louis & San Francisco															
1907	13235	0.48 0.58	0.10	0.80 1.10	0.20	0.05		50000	50000		%	5				5	35	15	40					5	15	20		15.1
											No.	1				1	7	3	8									
								Illinois S. Works			%																	
											No.		St. Louis & San Francisco															
1898 1907	2935	0.48 0.58	0.10	0.80 1.10	0.20	0.05		50000	50000		%		50				16		34						6	6		20.4
											No.		3				1		2									
								Maryland			%																	
											No.		Southern Railway															
1905	6200	0.48 0.58	0.10	0.80 1.10	0.20			44000	52000		%		33				33	17	17					1	5	6		9.7
											No		2				2	1	1									
								Carnegie			%																	
											No.		Southern Railway															
1903 1907	10472	0.43 0.58	0.10	0.80 1.10	0.20			45000	54000		%	9				36	23	23	9					15	7	22		21.0
											No.	2				8	5	6	2									
								Cambria			%																	
											No.		Southern Railway															
1907	11085	0.48 0.55	0.10	0.80 1.10	0.20						%	17					50	17		17				3	3	6		5.4
											No.	1					3	1		1								

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909

24

85 lb. Various Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail. Millions		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
												Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve			
	A.S.C.E. Section							Carnegie			%																	
											No.		Vandalia R.R. (St. Louis Division)															
1903 1907	10334	0.40 0.60	0.07 0.10	1.0 1.2				57500	55500	9.6	%		13			22	6	50	6	3								
											No.		4			7	2	16	2	1				24	8	32	21.4	31.0
	A.S.C.E. Section							Cambria			%																	
											No.		Vandalia R.R. (St. Louis Division)															
1905 1907	5751	0.40 0.60	0.07 0.10	1.0 1.2				57500	55500	9.6	%					20		40	40									
											No.					1		2	2					3	2	5	15.2	8.7
	A.S.C.E. Section.							Illinois			%																	
											No.		Vandalia R.R. (St. Louis Division)															
1900	2736	0.40 0.60	0.07 0.10	1.0 1.2				57500	55500	9.6	%																	
											No.	2												2		2		7.3
											%																	
											No.																	
											%																	
											No																	
85 lb. Great Northern Sec								Lackawanna Steel Co.			%																	
											No.		Great Northern															
1906 1907	54607	0.48 0.58	0.10	0.80 1.10	0.20						%	4	2		4	6	63	4	7	2	2	4	2					
											No.	2	1		2	3	34	2	4	1	1	2	1	10	43	53		9.7
85 lb. Great Northern Sec.								Illinois Steel Co.			%																	
											No.		Great Northern															
1906 1908	48354	0.43 0.58	0.10	0.80 1.10	0.20						%		1	4		23	14	30	13			15						
											No.		1	3		19	12	25	11			13		60	24	84		11.2
											%																	
											No																	
85 lb. A.S.C.E. Sec. Nickel Steel								Carnegie Steel Co.			%																	
											No		Pennsylvania Lines West						N.W. System									
1903 1907	1655	0.44	0.09	0.80	0.10	0.03	Nickel 3.42	51500	61800		%																	
											No.					3								3		3	229.6	18.1

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

85 lb. P.S. Section Bessemer Steel. Rolled by Various Steel Co. Record for period of 6 month ~~one year~~ ending Oct. 31 1909 25

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
											%																	
								Cambria			No.		Pennsylvania R.R. Lines East															
											%	10			10				10	20	50							
1909	3933	0.50	0.08	1.00	0.13			65000	61700		No	1			1				1	2	5			3	7	10		25.4
											%																	
								Maryland			No.		Pennsylvania Lines West N. W. System															
											%																	
1908	500	0.50	0.10	1.00	0.12			51500	61800		No				1				1						2	2		40.0
											%																	
								Cambria			No.		Pennsylvania Lines West N W System															
											%																	
1908 1909	1026	0.50	0.10	1.00	0.12			51500	61800		No							2						2		2		19.5
											%																	
								Carnegie			No		Pennsylvania Lines West N. W. System															
											%		1		7	9	48	9	21	1	4							
1909	2045	0.50	0.10	1.00	0.12			51500	61800		No		1		5	6	34	6	15	1	3			13	58	71		347.1
											%																	
								Illinois			No		Pennsylvania Lines West N. W. System															
											%																	
1909	1266	0.50	0.10	1.00	0.12			51500	61800		No																	
											%																	
								Carnegie			No.		Pennsylvania Lines West S. W. System															
											%					5	57		38									
1909	2063	0.50	0.10	1.00	0.12			58800	61600		No.					1	12		8					1	20	21		101.8
											%																	
								Cambria			No		Pennsylvania Lines West S. W. System															
											%																	
1908 1909	469	0.50	0.10	1.00	0.12			58800	61600		No																	
											%																	
								Illinois S. Works			No		Pennsylvania Lines West S. W. System															
											%																	
1909	9987	0.50	0.10	1.00	0.12			58800	61600		No	1												1		1		1.0
											%																	
								Illinois			No.		Pennsylvania Lines West S. W. System															
											%																	
1909	48	0.50	0.10	1.00	0.12			58800	61600		No.																	
											%																	
1908 1909								Maryland			No		Pennsylvania Lines West S. W. System															
~~Totals~~	463	0.50	0.10	1.00	0.12			58800	61600																			

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

85 lb. Various Section Bessemer Steel. Rolled by Various Steel Co.

Record for period of 6 months ~~one year~~ ending October 31 1909 26

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
												Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
											%																	
		A.R.A. "A" Section						Illinois			No.		Atchison Topeka & Santa Fe (Illinois Div)															
											%																	
1909	1607							82 Tons	101 Tons		No.			1						1				2		2.		12.4
											%																	
		A.R.A. "A" Section									No:		Atchison Topeka & Santa Fe (Middle Div)															
											%					11	11	34	11	11	11	11						
1906	8282							72 Tons	72 Tons		No.					1	1	3	1	1	1	1		6	3	9		10.9
											%																	
		A.R.A. "A" Section						Colorado Fuel & Iron Co.			No.		Atchison Topeka & Santa Fe (Los Angeles Div)															
											%																	
1909	7043										No.																	
											%																	
											No.																	
											%																	
											No.																	
											%																	
		C.B.&Q. Section						Carnegie			No.		Chicago Burlington & Quincy															
1906 1907	8300	0.48 0.58	0.10	0.80 1.10	0.20						%	6½	6½		1½	18	18	28	17		3		1½					
											No.	4	4		1	11	11	17	10		2		1	32	29	61		73.5
											%																	
		C. B.& Q. Section						Colorado Fuel & Iron Co.			No.		Chicago Burlington & Quincy															
1905 1909	115750	0.48 0.58	0.10	0.80 1.10	0.20						%	3	3		6	12	23	14	21	3	6	9						
											No.	1	1		2	4	8	5	7	1	2	3		14	20	34		2.9
											%																	
		C.B.& Q Section						Illinois			No.		Chicago Burlington & Quincy															
1904 1909	239820	0.48 0.58	0.10	0.80 1.10	0.20	From 1906-1909					%	3½	10		½	18	26	21½	11	3½	½	4	2½					
											No.	7	20		1	38	53	44	23	7	1	8	5	104	103	207		8.6

85 lb ASCE Section Open Hearth Steel. Rolled by Various Steel Co

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909

27

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail. Millions			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve		Last Year	Present Year
												%																	
								Bethlehem				No.		Boston & Maine															
												%																	
1909	8220	0.62 0.75	0.04	0.60 0.90	0.06			33600	32800			No.									1				1		1		1.2
												%																	
								Tennessee Coal & Iron				No.		Illinois Central															
												%	4	28	16	20	16	18	4		4								
1907 1908	11833	0.55 0.65	0.06	0.80 1.10	0.20			48500	46000			No.	1	7	4	5	4	2	1		1				11	14	25	13.1	21.1
												%																	
								Cambria				No.		Norfolk & Western															
												%																	
1909	4000	0.62 0.75	Max 0.04	Max 0.08	0.05 0.20	0.04		46000	45000	[illegible]		No			1				1						2		2		5.0
												%																	
								Pennsylvania				No		Norfolk & Western															
												%																	
1909	6000	0.62 0.75	Max 0.04	Max 0.80	0.05 0.20	0.04		46000	45000			No.																	
												%																	
								Bethlehem				No		Norfolk & Western															
												%																	
1909	2500	0.62 0.75	Max 0.04	Max 0.80	0.05 0.20	0.04		46000	45000			No																	
												%																	
								Carnegie				No.		Norfolk & Western															
												%																	
1909	3000	0.62 0.75	Max 0.04	Max 0.08	0.05 0.20	0.04		46000	45000	1.00		No				1										1	1		3.3
												%																	
								Tennessee Coal Iron & R.R. Co				No		Norfolk & Western															
												%																	
1904	500	0.58	0.05	0.94	0.09	0.04		44000	45000			No																	
												%																	
								Tennessee Coal Iron & R.R. Co.				No		Pennsylvania Lines West S.W. System															
												%																	
1904	480							58800	61600			No																	
												%																	
								Illinois Gary				No		Rock Island Lines															
												%																	
1909	1749	0.59 0.72	0.04	0.60 0.90	0.10 0.20			53000	53550			No.																	

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with same period of previous year.

85 lb. Various Section Open Hearth Steel. Rolled by Various Steel Co. Record for period of ~~one year~~ 6 months ending Oct. 31 1909 28

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
												%																	
	A.S.C.E. Sec.							Tennessee Coal & Iron Co.				No.		St. Louis & San Francisco															
												%																	
1906	10000	0.65 0.75	0.04	0.75 1.00	0.10 0.20	0.06		50000	50000			No.	1												1		1		1
												%																	
	A.S.C.E. Sec.							Tennessee Coal		Iron & R.R. Co		No.		Southern Ry															
												%	23	5			13	13	9	23	5	5	4						
1905 1908	33441	0.55 0.65	0.06	0.80 1.10	0.20			44000	52000			No.	5	1			3	3	2	5	1	1	1		12	10	22		6.6
												%																	
												No.																	
												%																	
	P.S. Section							Bethlehem				No.		Pennsylvania R.R. Lines, East															
												%																	
1909	2494	0.85	0.12	0.65	.041							No.				1										1	1		4.0
												%																	
	P.S. Section				Open Hearth			"A" Carnegie				No.		Pennsylvania Lines West N.W. System															
												%																	
1909	1001	0.70 0.83	0.03	0.80	0.05 020							No.							1						1		1		10.0
												%																	
	P.S. Section				Open Hearth			"A" Carnegie				No.		Pennsylvania Lines West S.W. System															
												%																	
1909	426	0.70 0.83	0.03	0.80	0.05 0.20			58800	61600			No.																	
												%																	
	P.S. Section				Open Hearth			"A" Illinois		Gary		No.		Pennsylvania Lines West S.W. System.															
												%																	
1909	1764	0.70 0.83	0.03	0.80	0.05 0.20			58800	61600			No	1		1					1		1			2	2	4		22.7
												%																	
	P.S. Section.				Open Hearth "B"			Carnegie				No		Pennsylvania Lines West N.W. System															
												%																	
1909	1153	0.62 0.75	0.04	0.80	0.05 0.20							No																	
												%																	
	P.S. Section				Open Hearth			"B" Carnegie				No.		Pennsylvania Lines West S.W. System.															
												%																	
1909	10	0.62 0.75	0.04	0.80	0.06 0.20			58800	61600			No.																	
												%																	
	P.S. Section				Open Hearth			"B" Illinois		Gary		No.		Pennsylvania Lines West S.W. System															
												%																	
1909	1567.	0.62 0.75	0.04	0.80	0.06 0.20			58800	61600			No.																	

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with same period of previous year

Record for period of ~~one year~~ 6 months ending Oct. 31 1909 29

85 lb. Various Section Open Hearth Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
		C.B.&Q. Sec						Bethlehem				%																	
												No.		Chicago Burlington & Quincy															
1908	10000	0.48 0.58	0.10	0.80 1.10	0.20							%						12½	25	12½	25		25						
												No						1	2	1	2		2		6	2	8		8.0
												%																	
												No.																	
												%																	
												No																	
		Great Northern Sec.						Tennessee Coal & Iron Co.				%																	
												No.		Great Northern															
1906	10043	0.55 0.65	0.06	0.80 1.10	0.20							%	7	3			13	44	17	3	3			10					
												No	2	1			4	13	5	1	1			3	12	18	30	32.0	30.0

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of 6 months ~~one year~~ ending Oct. 31 1909 30

80 lb. ASCE Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger	Millions			Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
								Maryland				%																	
												No.		Central New England															
1907 1909	3787	0.57	065	0.98	.088	.056		38900	40000			%																	
												No									1				1		1		2.7
								Illinois				%																	
												No.		Chicago & Eastern Illinois															
1891 1908	43643	0.43 0.53	.095 0.10	1.00 1.10	0.20	.039		47300	51500			%	67	16½						16½									
												No.	4	1						1					4	2	6		1.4
								Illinois				%																	
												No.		Chicago & Northwestern															
1894 909	85975											%	80	10				10											
												No	8	1				1							8	2	10		1.2
								Carnegie				%																	
												No			C. C. C. & St. L.														
1898 1708	115094	0.43 0.58	0.10	0.80 1.10	0.20			52000	53000	5½		%	4½	3/4	3/4	1/2	30	8½	40	12	2	1/4	3/4						
												No	29	4	5	3	200	55	259	81	13	1	5		511	144	655	66.9	56.9
								Lackawanna				%																	
												No			C. C. C. & St. L														
1904 1905	11550	0.48 0.58	0.10	0.80 1.10	0.20			52000	53000	19.92		%				6	70		18		6								
												No.				1	12		3		1				16	1	17	20.1	14.7
								Illinois				%																	
												No.			C. C. C & St. L														
1903 1907	19950	0.43 0.58	0.10	0.80 1.10	0.20			52000	53000	10.90		%					60	20			20								
												No.					3	1			1				4	1	5	4.3	2.5
								Lackawanna & Pennsylvania.				%																	
												No			Delaware Lackawanna & Western														
1903 1908	38799											%	42	29					12½		8½	4	4						
												No	10	7					3		2	1	1		16	8	24		6.5
								Illinois				%																	
												No			Evansville & Terre Haute														
1899 1902	2308											%													1				
												No.	1														1		43
								Carnegie				%																	
												No			Evansville & Terre Haute														
1899 1904	3165											%																	
												No.																	
												%																	
												No																	
Totals																													

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909 31

80 lb. ASCE Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
													Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve			
								Colorado Fuel & Iron				%																	
												No.		Galveston Harrisburg & San Antonio															
1901	2832	0.54	.134	0.97	.191	.072		51266	53330			%					34	33		33									
												No.					1	1		1					1	2	3		10.6
								Carnegie				%																	
												No.		Galveston Harrisburg & San Antonio															
1901 1906	42938	0.43 0.51	0.91 1.07	0.40 1.13	.097 .170	.038 .088		51266	53330	20		%	14			2	36	12	29	7									
												No.	6			1	15	5	12	3					33	9	42		9.8
								Maryland				%																	
												No.		Galveston Harrisburg & San Antonio															
1906	2294									15		%																	
												No.										1				1	1		4.4
								Cammell				%																	
												No		Grand Trunk															
1902	2175							48720	45976			%																	
												No.							2						2		2	32.2	9.2
								Carnegie				%																	
												No.		Grand Trunk															
1903 1905	92824							47264	45876			%	1				14		68		14		3						
												No.	1				11		55		11		3		81		81	17.9	8.7
								Dominion Iron & Steel Co.				%																	
												No.		Grand Trunk															
1905	12687	0.50 0.60	.06	1.10 1.30	0.15 0.20	.069		49532	48720			%	15				3		67		12		3						
												No	5				1		22		4		1		33		33	37.0	26.0
								National				%																	
												No		Grand Trunk															
1902	3000							47264	45876			%	22				22		56										
												No	2				2		5						9		9	120.	30.
								Illinois				%																	
												No		Grand Trunk															
1905	19650							47264	45876			%	60				20		20										
												No	3				1		1						5		5	9.2	2.5
								Lackawanna				%																	
												No		Grand Trunk															
1907	8062	0.48 0.58	0.10	0.80 1.10	0.20			49532	45976			%	10				60		20		10								
												No.	1				6		2		1				10		10	19.8	12.4
												%																	
												No																	
Totals																													

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year

Record for period of 6months ~~one year~~ ending Oct.31 1909

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80 lb. A.S.C.E Section Bessemer Steel Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail. *Millions*			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
													Tang.	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve			
								Carnegie				%																	
												No.	Houston & Texas Central																
1902 1903	17478	0.45 0.55										%																	
												No																	
								Maryland				%																	
												No.	Houston & Texas Central																
1904 1907	20250	0.50 0.60	.085	0.80 1.10	0.28	.075						%																	
												No.																	
								National				%																	
												No.	Lake Shore & Michigan Southern																
1901	7934											%																	
												No.																	
								Carnegie				%																	
												No	Lake Shore & Michigan Southern																
1896 1903	60086	0.40 0.50	0.10	0.75 1.05	0.20			55500	44600			%	1½	1½			11	1½	71	5½	5½		2½						
												No	1	1			8	1	52	4	4		2		67	6	73		12.1
								Illinois				%																	
												No	Lake Shore & Michigan Southern																
1901 1909	94143	0.40 0.50	0.10	0.75 1.05	0.20			55500	58400			%	7	7			4	4	11	33	4	4	15	11					
												No	2	2			1	1	3	9	1	1	4	3	11	16	27		2.9
								Illinois				%																	
												No.	Lake Superior & Ishpeming																
1896 1904	2500	.480	.090	0.92	.094			48250	32600	1½		%		7		29		21		43									
												No.		1		4		3		6						14	14		66.0
								Pennsylvania & Maryland				%																	
												No	Lehigh & Hudson River																
1904 1908	8474	0.65 0.80	0.06	0.70 1.00	0.20			42500	47500			%	6		6		23		12	12	12	17		12					
												No	1		1		4		2	2	2	3		2	10	7	17		20.1
								Carnegie				%																	
												No	Louisiana Western																
1903	9994							42000	46000	20		%																	
												No.	1						1						2		2	5.1	2.0
								Lackawanna				%																	
												No.	Marquette & Southeastern																
1907 1908	1941	0.48 0.58	0.10	0.75 1.05	0.20			48250	32600	½		%																	
												No.																	
												%																	
												No.																	
Totals																													

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909

33

80 lb. A.S.C.E. Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis					Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail. Millions		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.	Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
											Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve			
										%																	
							Lackawanna & Illinois			No.		Memissing Ry															
1906	2083	0.48 0.58	.039 0.10	0.80 1.10	.094 0.20	Second Quality	48250	32600	¼	%																	
										No																	
										%																	
							Algoma			No.		Michigan Central															
1902	5149	.446	.097	.901	107	052	44000	47000	47	%																	
										No.																	
										%																	
							Carnegie			No.		Michigan Central															
1903	8400	.468	.096	.92	.043	.044	52000	48000	40	%	11	11			11		62	5					16	3	19	17.6	22.6
										No.	2	2			2		12	1									
										%																	
							Carnegie & National			No		Michigan Central															
1902	13472	.466	.094	0.93	.053	.047	52000	48000	47	%	5				2		74	11			8		34	4	38	7.7	28.2
										No	2				1		28	4			3						
										%																	
							Lackawanna			No		Michigan Central															
1901	15755	.538	.065	1.17	0.14	.066	44000	47000	54	%	14						43	29			14		5	2	7	17.8	4.4
										No.	1						3	2			1						
										%																	
							Colorado Fuel & Iron Co.			No.		Oregon Short Line															
1901 1905	29736	0.45 0.56	.085 0.10	0.80 1.10	0.10 0.20	075	24 35/100	26½ Tons		%	50	9			17		8	8	8				10	2	12		4.0
										No.	6	1			2		1	1	1								
										%																	
							Illinois			No		Oregon Short Line															
1902 1903	5152	0.43 0.53	0.10	0.80 1.10	0.20		24 35/100	26½ Tons		%		33					67						2	1	3		5.8
										No		1					2										
										%																	
							Carnegie			No.		Oregon Short Line															
1904	7613	0.55	.085	.80 1.10	0.20	.075	24 35/100	26½ Tons		%	10½	5			16	10½	27	31					10	9	19	27.3	25.0
										No	2	1			3	2	5	6									
										%																	
							Carnegie			No.		Pittsburg & Lake Erie R/R.							P. McK. & Y Div.								
1901 1909	16915	0.45 0.55	0.10	0.80 1.10	0.20		42000	52000		%	7	5			7	3½	22	45	5	2		3½	24	35	59		349
										No.	4	3			4	2	13	27	3	1		2					

As shown below Railroad.

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909

34

80 lb. ASCE Section Bessemer Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.				Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
														Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger					Tang	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
													%																	
								Illinois					No.		Rock Island Lines															
													%	50	10				5	5		25		5						
1897 1909	262541	After 1904 0.48 0.58	0.10	0.80 1.10	0.20			53000	53550				No	10	2				1	1		5		1		17	3	20		0.8
													%																	
								Pennsylvania					No.		Rock Island Lines															
													%						60		20		20							
1903 1905	6331	0.43 0.53	0.10	0.80 1.10	0.20			53000	53550				No.						3		1		1				5	5	92.2	7.9
													%																	
								Maryland					No.		Rock Island Lines															
													%																	
1902 1906	15943	After 1904 0.48 0.58	0.10	0.80 1.10	0.20			53000	53550				No.	1				1								2		2		1.3
													%																	
								Carnegie					No.		Rock Island Lines															
													%																	
1903 1904	225	0.43 0.53	0.10	0.80 1.10	0.20			53000	53550				No																	
													%																	
								Lorain		See addition of Rock Island Lines			No.		Rock Island Lines															
													%																	
1902 1904	20560	0.43 0.53	0.10	0.80 1.10	0.20			53000	53550	on Sheet 35.			No.																	
													%																	
								Illinois					No.		St. Joseph & Grand Island															
													%																	
1903 1905	9159												No.																	
													%																	
								Various Mills					No		Southern Pacific															
													%	15				20	5	38	12	8	2							
1903 1905	47311	0.45 0.55	.085	0.75 1.00	0.20	0.75		51700	58400				No	9				12	3	22	7	6	1			48	11	59		12.5
													%																	
								Cambria					No		Southern Railway															
													%																	
1900 1905	10000	0.48 0.65	0.10	0.80 1.10	0.20			44000	52000				No.		1				1								2	2		2.0
													%																	
								Maryland					No		Southern Railway															
													%	25	25						50									
1901 1902	20000	0.40 0.60	0.10	0.75 1.05	0.20			38000	41000				No.	1	1						2					1	3	4		2.0

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

80 lb ASCE Section. Bessemer Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909 35

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis C.	P.	Mn.	Si.	S.		Maximum Axle Load of Locomotives. Freight	Passenger	Approximate Gross Tons over Rail.	
								Carnegie			
1903 1907	12113	0.45 0.55	0.10	0.75 1.05	0.20			45000	54000		
								Cammell Steel Co England			
1905 1906	6552	0.50 0.60	0.07	0.80 1.00	0.10 0.15	0.07		40000	40000		
								Carnegie			
1904	7232										
								Illinois			
1899 1904	37224	0.43 0.53	0.10	0.80 1.10	0.20			28 Tons	71 Tons		
								Colorado Fuel & Iron Co.			
1900 1906	59905	0.48 0.58	0.10	0.80 1.10	0.10 0.20	.075		24 Tons	28 Tons		
								Lorain			
1904	492	0.50 0.60	.085	0.80 1.10	0.20	.075		24 Tons	28 Tons		
								National			
1901 1902	4141	0.43 0.53	0.10	0.80 1.10	0.20			53000	53550		

	Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
	Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
%																	
No.		Southern Railway															
%		29			14	29	14	14									
No.		2			1	2	1	1					2	5	7		5.8
%																	
No.		Temiskaming & Northern Ontario															
%																	
No.	3												3		3		4.6
%																	
No.		Union Pacific															
%	6	5		1½		1½	49	21	8	5	1½	1½					
No.	4	3		1		1	31	13	5	3	1	1	41	22	63	61.5	87.1
%																	
No.		Union Pacific															
%	24				4		36	24	4	4	4						
No.	6				1		9	6	1	1	1		18	7	25	7.8	6.7
%																	
No.		Union Pacific															
%	15		1½	1½	17	1½	36	20	6		1½						
No.	9		1	1	10	1	22	12	4		1		47	14	61	10.5	10.2
%																	
No.		Union Pacific															
%							67	33									
No.							3	1					2	1	3	119.2	60.9
%																	
No		Rock Island Lines															
%																	
No																	

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

80 lb. Various Section Bessemer Steel Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending October 31 1909

36

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
											%																	
			A.S.C.E. Sec.					Maryland			No.		N.Y.N.H.&H.R.R.															
1907 1908	17565	0.57 0.65	0.07	0.80 1.05	0.20	0.06		45000	44000		%		20				10		10	20	10	30				10		5.7
											No.		2				1		1	2	1	3		5	5			
											%																	
											No.																	
											%																	
			80 lb. Dudley Sec.					Carnegie			No.		Hocking Valley															
1906	3140							41000	46000		%	50				17		33								6		19.1
											No.	3				1		2						6				
											%																	
			80 lb. Dudley Sec.					Lackawanna			No.		New York Central & Hudson River - Main Line - West Shore.															
1899 1908	58899	35:45 .40:.50	0.10	0.80 1.00	0.10 0.13	} 1908		27.1 Tons	29.8 Tons		%	12½	25				12½	12½	37½							8		1.4
											No.	1	2				1	1	3					2	6			
											%																	
			80 lb. Dudley Sec.					Lackawanna			No.		New York Central & Hudson River - Side Lines															
1899 1908	49790	.35-.45 .40-.50	0.10	0.80 1.00	0.10 0.13	0.09}	1908	27.1 Tons	27.5 Tons		%	47	13					13	27							15		3.0
											No.	7	2					2	4					9	6			
											%																	
			80 lb. Dudley Sec.					Carnegie			No.		New York Central & Hudson River - Main Line & West Shore.															
1899 1905	51165	0.43 0.65	0.10	0.80 1.30	0.15 0.20	.069		27.1 Tons	29.8 Tons		%	30½	23				8		8	30½						13		2.5
											No.	4	3				1		1	4				8	5			
											%																	
			80 lb. Dudley Sec					Carnegie			No.		New York Central & Hudson River - Side Lines.															
1899 1904	32051	0.43 0.63	0.10	0.80 1.30	0.16 0.20	.069		27.1 Tons	27.5 Tons		%	16	37					16	31							19		5.9
											No.	3	7					3	6					6	13			
											%																	
			80 lb. Dudley Sec.					Carnegie			No.		Pittsburgh & Lake Erie						P.McK. & Y. Division									
1909	3500	0.45 0.55	0.10	0.80 1.10	0.20			42000	52000		%		25						75							4		11.4
											No.		1						3						4			
											%																	
			80 lb. Dudley Sec.					Carnegie			No.		Toledo & Ohio Central															
1903 1909	8312							18500	23125		%	4	4			29	13	34	4	8	4					24		28.9
											No.	1	1			7	3	8	1	2	1			18	6			

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

80 lb. Various Section Bessemer Steel. Rolled by Various Steel Co.

Record for period of 6 months ~~one year~~ ending Oct. 31 1909

37

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail. *Millions*		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si	S.		Freight	Passenger			Tang.	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
		Gr't Northern Sec						Republic			%																	
											No.		Great Northern															
1905	2477	0.48 0.58	0.10	0.80 1.10	0.20						%	13					13	25				49						
											No	1					1	2				4		7	1	8		32 3
		Gr't Northern Sec.						Lackawanna			%																	
											No		Great Northern															
1905 1908	10880	0.48 0.58	0.10	0.80 1.10	0.20						%	14				42	11	17	3			8	5					
											No.	5				15	4	6	1			3	2	29	7	36		33.1
		Gr't Northern Sec.						Illinois			%																	
											No		Great Northern															
1904 1907	39175	0.43 0.58	0.10	0.80 1.10	0.20						%	8	1			5	1	10	1	5		65	4					
											No	7	1			4	1	9	1	4		56	3	80	6	86		21.9
											%																	
											No																	
		A.S.C.E. Sec.								Illinois	%																	
											No	Oregon R.R. & Nav. Co. & Southern Pacific Co Lines in Oregon																
1904 1905	27491	0.42 0.49	.077 .118	0.80 1.10	.081 .184	0.34 0.36		46725	53333	13.14	%		4			30	30	4	22	5			5					
											No.		1			7	7	1	5	1			1	9	14	23		8.4
											%																	
											No.																	
		80 lb. A.S.C.E Sec.						Cammell			%																	
											No.		Temiskaming & Northern Ontario															
1903 1904	17388	0.50 0.60	0.07	0.80 1.00	0.10 0.20	.075		40000	40000		%	8	4			6	26	8	30			10	8					
											No.	4	2			3	13	4	15			5	4	16	34	50		28.8
											%																	
											No																	
		80 lb. Special Sec.					No	540	Cambria		%																	
											No		Hocking Valley															
1904	2500							41000	46000		%																	
											No.	1												1		1		4.0

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with same period of previous year.

Record for period of ~~one year~~ ending Oct. 31 1909 38

80 lb. A.S.C.E Section Open Hearth Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail. Millions			Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
													Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
								Pennsylvania.				%																	
												No.		Central New England															
1909	1235	0.77	.015	.035		0.75		39800	40000			%																	
												No											1		1		1		8.1
								Tennessee Coal Iron & R.R. Co.				%																	
												No		C. C. C. & St. Louis R.R															
1905	1050	0.66 0.65	0.06	0.80 1.10	0.20			52000	53000	19.90		%																	
												No																	
								Tennessee Coal Iron & R.R. Co.				%																	
												No.		Galveston Harrisburgh & San Antonio															
1904 1905	7007	0.60		.085	0.80 1.10	0.20	.075	51266	53330	15		%	40	20				20		20									
												No	2	1				1		1					2	3	5		7.1
								Dominion Iron & Steel Co.				%																	
												No		Grand Trunk															
1906	26974	0.55 0.65	0.05	0.85 1.10	0.15	0.05		49532	45976			%	6		4		48		25		7		11						
												No	8		5		71		34		10		16		144		144	100.8	53.4
								Tennessee Coal Iron & R R. Co				%																	
												No		Louisville & Nashville															
1905 1909	119726	0.55 0.68	006	0.80 1 10	0.20			43000	41000	3.59		%	14	7	1	7	5	4	16	17	15	12		2					
												No.	16	8	1	8	5	4	18	19	17	14		2	57	55	112		9.4
								Tennessee Coal Iron & R.R. Co.				%																	
												No.		Nashville Chattanooga & St. Louis															
1903 1908	16261	0.52 0.65	0.04	0.60 0 90	0.20			46000	46000			%		10		23		7	7		7	46							
												No.		3		7		2	2		2	14			4	26	30		18.4
								Tennessee Coal & Iron Co				%																	
												No		Rock Island Lines															
1903	123	056	0.40	0.82	.006			53000	53550			%																	
												No																	
								Tennessee Coal Iron & R R. Co.				%																	
												No		Southern Railway															
1904 1909	58833	0 59 0.72	0 04 0.06	0.60 1.10	0.20			45000	54000			%	28	28			6	6	6	6	6	14							
												No	4	4			1	1	1	1	1	2			7	8	15		2 6
												%																	
												No																	
		N. Y. N. H. & H. Sec.						Bethlehem				%																	
												No		New York New Haven & Hartford															
1909	975	0.70 0 75	.026 .036	0 70 0 99	.121 .181	040 052		33000	33500			%																	
												No.	1												1		1		10.3
Totals																													

_____________As shown below___ Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

78 lb. N.Y.N.H.&H. Section Bessemer Steel. Rolled by Various Steel Co. Record for period of 6 months ~~one year~~ ending October 31 1909 39

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si	S.		Freight	Passenger			Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
											%																	
								Maryland			No.	New York New Haven & Hartford																
											%																	
1906	12072							45000	40000		No.		1								1				2	2		1.7
											%																	
											No.																	
											%																	
								Lackawanna			No.	New York New Haven & Hartford																
											%																	
1903	1885							45000	44000		No.		1												1	1		5.3
											%																	
											No.																	
											%																	
								Carnegie			No	New York New Haven & Hartford																
											%																	
1904	4000	0.40 0.50	0.10	0.75 1.05	0.20			45000	44000		No.								1		1				2	2		5.0

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

75 lb. ASCE Section Bessemer Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending October 31 1909

40

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail. Millions			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
												%																	
								Lackawanna Buffalo				No.		Boston & Maine															
1904 1907	17440	0.43 0.53	0.10	0.80 1.10	0.20							%	11	16				24	6	8		3	24	8					
								33600	32720			No	4	6				9	2	3		1	9	3	15	22	37		21.2
												%																	
								Lackawanna Scranton				No.		Boston & Maine															
1890 1901	64548	0.43 0.53	0.10	0.80 1.10	0.20							%	16	8	2	4	2	23	4	8	10	13	8	2					
								33600	31300			No	9	4	1	2	1	12	2	4	5	7	4	1	22	30	52		8.1
												%																	
								Maryland				No.		Boston & Maine															
1892 1903	19439	0.43 0.53	0.10	0.80 1.10	0.20							%	11	4½			2¼	4½	13	9	29	20	2¼	4½					
								33600	31300			No	5	2			1	2	6	4	13	9	1	2	26	19	45		23.2
												%																	
								Bethlehem				No		Boston & Maine															
1891 1896	23700	0.43 0.53	0.10	0.80 1.10	0.20							%	5				30		35	20	5		5						
								31100	31100			No	1				6		7	4	1		1		16	4	20		8.4
												%																	
								Pennsylvania				No		Boston & Maine															
.892 .897	8423	0.43 0.63	0.10	0.80 1.10	0.20							%									57	43							
								31100	31100			No									4	3			4	3	7		8.3
												%																	
								Colorado Fuel & Iron Co.				No.		Fort Worth & Denver City															
1903 1906	25768											%	34	16			34		16										
								194650	187700			No	2	1			2		1						5	1	6		2.3
												%																	
								Illinois				No		Illinois Central															
896 1907	129812	0.40 0.50	0.10	0.75 1.05	0.20	0.075						%	47	41				6			6								
								48500	46000			No	8	7				1			1				9	8	17	.33	1.3
												%																	
								Carnegie				No		Illinois Central															
1897 1901	6960	0.40 0.50	0.10	0.75 1.05	0.20							%																	
								48500	46000			No							3						3		3	3.9	4.3
												%																	
								Maryland				No		Norfolk & Western															
1902 1904	6000	0.55	0.09	1.10	0.10	0.04						%						33	50	17									
								44000	45000			No						2	3	1					3	3	6	20.	10.0
												%																	
												No.																	
Totals																													

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

75 lb. Various Section Bessemer Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending Oct. 31st. 1909

41

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si	S.		Freight	Passenger				Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
												%																	
		A.S.C.E. Sec						Carnegie. Ohio Works				No		St Louis & San Francisco															
1897 1907	14225	0.48 0.50	010	0.80 1.10	0.20			50000	50000			%	8				11	27	23	27	4								
												No	2				3	7	6	7	1				12	14	26		.153
												%																	
		A.S.C.E. Sec						Illinois				No.		St Louis & San Francisco															
1895 1902	32675	0.48 0.50	0.10	0.80 1.10	0.20			50000	50000			%	10	40				20	10	10		5		5					
												No	2	8				4	2	2		1		1	4	10	20		6.1
												%																	
		A.S.C.E. Sec						Carnegie				No		Southern Railway															
1903 1907	29023	0.45 0.55	0.10	0.75 1.05	0.20			45000	54000			%	18	46				27	9										
												No	2	5				3	1						3	8	11		3.8
												%																	
		A.S.C.E. Sec						Lorain Carnegie & Illinois				No		Toledo St Louis & Western.															
1905 1907	29795	0.40 [illegible]	0.10	[illegible]	0.20							%					30	30	[illegible]	[illegible]	5	15							
												No					6	6	3	1	1	3			10	10	20		6.7
												%																	
												No																	
												%																	
	Common Standard Harriman Lines Sec								Carnegie			No		Galveston Harrisburgh & San Antonio															
190[illegible] 1908	30565	045	107	0.74	091	041		51266	53330			%	10				20	35	20	5	10				12	8			
												No	2				4	7	4	1	2						20	6.5	6.5
												%																	
	C.S. Sec.							Pennsylvania				No		Galveston Harrisburgh & San Antonio															
1909	603							51266	53330			%																	
												No					1								1		1		16.6
												%																	
	C.S. Sec							Carnegie				No		Houston & Texas Central															
1896 1905	10119	0.45 0.85	085	0.80 1.10	0.20	.075						%																	
												No																	
												%																	
	C.S. Sec							Maryland				No		Houston & Texas Central															
1906	721	0.50 0.60	.085	0.80 1.10	0.20	075						%																	
												No																	
												%																	
	C.S. Sec.							Tennessee Coal Iron & R.R. Co				No		Houston & Texas Central															
1907 1909	4859	0.60 0.60	085	0.80 1.10	0.20	.075		34000	26500			%																	
												No	1												1		1		2.1
Totals																													

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

75 lb. Common Standard Harriman Lines Section Bessemer Steel. Rolled by Various Steel Co.

Record for period of 6 months ~~one year~~ ending Oct. 31 1909

42

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
												Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
								Lackawanna			%																	
											No.		Louisiana Western															
1898	2634							42000	46000		%																	
											No.	1				1								2		2		7.6
								Lackawanna			%																	
											No.		Morgans Louisianna & Texas R.R.															
1901	1225							42000	46000	25.0	%																	
											No.							1						1		1		8.2
								Carnegie			%																	
											No.		Morgans Lousianna & Texas R.R.															
1895	5602							42000	46000		%	17						50	33									
											No.	1						3	2					4	2	6		10.6
								Carnegie			%																	
											No		Oregon R.R. & Nav. Co. & So. Pacific Co Lines in Oregon															
1905 1909	24919	0.44 0.63	118 .130	0.50 0.83	0.086 0.132	0.024 0.086		46725	53333	10.93	%	2½				50	16	16	8	5	2½							
											No.	2				39	12	12	6	4	2			57	20	77	60.2	30.9
								Carnegie	Ohio Works		%																	
											No.		Oregon Short Line															
1907	2344	0.45 0.55	.085	0.75 1.00	0.20	.075		24 35/100	26½ Tons		%	20				20		20		20		20						
											No.	1				1		1		1		1		5		5		21.3
								Illinois			%																	
											No.		St. Joseph & Grand Island															
1907	1526										%																	
											No.																	
								Various	Mills		%																	
											No		Southern Pacific															
1905 1908	32511	0.45 0.65	.085	0.75 1.00	0.20	.075		51700	58400		%	8	31		3	7	11	12	10	4	13	3/4	1/4					
											No.	25	96		10	23	35	38	31	12	41	2	1	100	214	314		96.6
								Illinois			%																	
											No.		Union Pacific															
1907 1908	18343	0.45 0.55	0.10	0.75 1.00	0.20	.075		24 Tons	28 Tons		%	11					11	45	33									
											No.	1					1	4	3					5	4	9	2.4	4.4

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

75-72 lb. Various Section Various Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909

43

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
	75 lb - B and M Sec							Lackawanna & Maryland				%																	
												No.		Maine Central															
1896		0.40	085	0.75								%	11	45								22	11	11					
1904	37063	0.60	100	1 30	0.20	069						No	1	4								2	1	1	2	7	9		2.4
	75 lb. B and M. Sec							Lackawanna				%																	
												No		Somerset Railway															
		0 50		0.75								%																	
1907	4200	0.60	.085	1.00	0 20	075						No																	
	75 lb C. and O. Sec							Carnegie				%																	
												No.		Chesapeake & Ohio															
1899												%																	
1900	22456							51000	48000			No				2										2	2		0.9
	75 lb C. and O. Sec							Maryland				%																	
												No		Chesapeake & Ohio															
												%																	
1903	4501							51000	48000			No								1						1	1		2.2
												%																	
												No																	
	75 lb. A.S.C.E. Sec					Open Hearth Steel		Tennessee C. I. & R.R.Co				%																	
												No		Southern Ry.															
1904		0.50		0.75								%	67	13							13		7						
1907	37491	0.60	0.06	1.05	0.20			45000	54000			No	10	2							2		1		13	2	15		4.0
												%																	
												No.																	
												%																	
												No																	
	72 lb. A.S.C.E. Sec.					Bessemer		Illinois				%																	
												No		Northern Pacific															
		0.40		0.75								%			33⅓					33⅓	33⅓								
1901	23199	0.50	0.10	1 05	0.20			54730	52300			No			1					1	1				2	1	3		1.3
	72 lb. A.S.C.E. Sec.					Bessemer		Lorain				%																	
												No.		Northern Pacific															
												%			25			25	50										
1901	3485							54730	52300			No			1			1	2						3	1	4		114
	72 lb. Special 7201					Bessemer		Illinois				%																	
												No		Chicago & North Western															
1890												%	35	11			11	1¾	27	9	1¾	1¼	1¾						
1909	202665											No	19	6			6	1	15	5	1	1	1		42	13	55		2.7
Totals																													

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909 44

Various lb. Various Section Bessemer Steel. ReRolled by McKenna Process ~~Steel Co.~~

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
		100 lb.		Rerolled	to		84 lb. —	Sec			%																	
											No.		Penna R.R. Lines East															
1907		0.50	0.08	1.00	0.12			65000	61700		%	25							75							4		
											No.	1							3					1	3			
											%																	
											No.																	
		90 lb.	N.Y.N.	H. &	H. Sec.						%																	
											No.		New York New Haven & Hartford															
1909	4213							45000	44000		%	25	11			8	5	19	19			5	8			37		84.6
											No.	9	4			3	2	7	7			2	3	21	16			
											%																	
											No.																	
		85 lb		A. S. C. E.		Sec.	Rerolled to	81 lb.			%																	
											No.		Penna Lines West					S.W. System										
1904 1905	460							58800	61600		%																	
											No.																	
											%																	
											No.																	
		80 lb.		A. S.	C.E.	Sec					%																	
											No.		Rock Island Lines															
1906 1909	19168							53000	53550		%															1		0.5
											No.	1												1				

Incomplete

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with same period of previous year

90 & 100 lb Various Section Various Steel. Rolled by Various Steel Co.

Record for period of ~~one year~~ 6 months ending October 31 1909

45

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail				Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
														Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C	P	Mn.	Si.	S.	Ni	Freight	Passenger					Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
													%																	
	100lb. P.R.R. Sec Bessemer Steel- Cambria, Carnegie, Maryland, Pennsylvania												No	Pennsylvania Railroad, Lines East																
1893								48350 to	56800 to				%	14	13	2	2½	4	5	8	8	26	15	2	¾					
1907		0.50	0.08	1.00	0.12			62900	62900				No	54	40	6	7	13	15	24	25	80	32	6	2	183	121	304		
													%																	
	100lb. P.R.R. Sec Nickel Steel Carnegie												No	Pennsylvania Railroad Lines East																
													%						17		66		17							
1903		0.51	0.08	0.84	0.11	0.05	3.25	48350	56800				No						1		4		1				6	6		
													%																	
	100lb P.R.R. Sec Open Hearth Pennsylvania												No	Pennsylvania Railroad Lines East																
1905													%	40							20	20	20							
1906		285	012	0.65	.041			65000	61200				No	2							1	1	1			3	2	5		
													%																	
	100lb. N.Y.N.H. & H. Sec Bessemer Steel Lackawanna, Maryland, Bethlehem.												No	New York New Haven & Hartford																
1893													%	9	8		6	17	8	15	23	6	[illegible]							
1908													No	5	4		3	9	4	8	12	3	4			25	27	52		
													%																	
													No																	
													%																	
													No																	
													%																	
													No																	
													%																	
	90lb. A.S.C.E Sec Bessemer Steel - Cambria, Pennsylvania, Maryland, Carnegie, Lackawanna												No	Lehigh Valley																
1900													%	8	8	¾	1½	40	9	11	8	4	6	1¼	2½					
1909								23.88	25.29 Tons				No	22	21	2	4	106	23	29	22	10	16	3	7	172	93	265		
													%																	
	90lb A.S.C.E. Sec Bessemer Steel - Carnegie												No	Pittsburgh & Lake Erie																
1898		0.45		0.80									%	10	7					55	24		4							
1900		0.55	0.10	1.10	0.20			42500	57000				No	3	2					16	7		1			19	10	29		
													%																	
	90lb A.S.C.E Sec. Open Hearth Bethlehem												No	Lehigh Valley																
1907		0.70		0.80									%	17	45	1½	3	1½	15		7		4		6					
1909		0.98	040	1.05				23.88	25.29 Tons				No	12	31	1	2	1	10		5		3		4	14	55	69		
													%																	
	A.S.C.E. Sec. Chrome, Nickel O.H. Bethlehem												No	Lehigh Valley																
		0.50		0.60		Chrom.	Ni.						%	17	17						66									
1909		0.60	040	0.90	0.20	0.40 0.75	2.0	23.88	25.29 Tons				No	1	1						4					1	5	6		
Totals																														

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of 6 months ~~one year~~ ending Oct. 31 1909

46

Incomplete

85-80 lb. Various Section Various Steel. Rolled by Various Steel Co.

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.				Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger					Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
														Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve			
													%																	
	85 lb P.R.R. Sec Bessemer							Cambria	Carnegie, Lackawanna, Maryland, Penna.				No.		Pennsylvania Railroad Lines East.															
													%	11	17	1		7	10	12	14	7	6	3	12					
1899 1907		0.50	0.08	1.00	0.12			65000	61700				No	31	50	4		21	30	33	42	20	17	10	34	119	173	292		
													%																	
	85 lb. A.S.C.E. Sec Bessemer							Maryland					No.		Baltimore & Ohio Southwestern															
													%					14	29	43			14							
1904													No					1	2	3			1			4	3	7		
													%																	
	85 lb. A.S.C.E. Sec. Bessemer							Pennsylvania					No.		Pennsylvania Railroad Lines East															
													%																	
1906		0.50	0.08	1.00	0.12			60000	60000				No									2				2		2		
													%																	
	85 lb. — Sec. Bessemer							Cambria, National, Tennessee Coal & Iron.					No		Cincinnati New Orleans & Texas Pacific															
													%	22½	33⅓					11	11	11	11							
1902 1908													No	2	3					1	1	1	1			4	5	9		
													%																	
	85 lb. — Sec Open Hearth							Tennessee Coal & Iron					No		Cincinnati New Orleans & Texas Pacific															
													%																	
1907 1908													No	2								1				3		3		
													%																	
													No.																	
													%																	
	80 lb. A.S.C.E Sec. Bessemer							Carnegie					No		Central Vermont															
													%	56	33						11									
1900 1906		040 050	0.10	070 090		005							No	5	3						1					5	4	9		
													%																	
	80 lb. A.S.C.E Sec. Bessemer							Carnegie, Cambria & Illinois					No		Chicago & Alton															
													%	25	7			10	4	21	2	17	6	3	5					
1905 1908													No	35	10			13	6	28	2	23	9	5	7	104	34	138		
													%																	
	80 lb. — Sec Bessemer							Tennessee Coal & Iron					No		Cincinnati New Orleans & Texas Pacific															
													%																	
1907													No	1												1		1		
													%																	
	80 lb — Sec Bessemer							Carnegie					No		Cleveland Cincinnati Chicago & St. Louis															
													%	3¼	¼	½	¼	8	1¼	74	12	¼		½						
890 897								52000	53000				No	11	1	2	1	27	4	253	40	1		2		296	46	342		
Totals																														

Incomplete

80 lb. ---- Section ---------- Steel. Rolled by ---------- Steel Co.

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 months ending Oct. 31 1909

47

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		C.	P.	Mn.	Si.	S.		Freight	Passenger				Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
													Tang.	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve			
	80 lb.	A.S.C.E. Sec. Bessemer.						Carnegie Lackawanna				%																	
												No.	Delaware Lackawanna & Western																
1892 1902												%	37	27			1	1	14	2	14	4							
												No.	38	28			1	1	15	2	14	4			68	35	103		
	80 lb.	A.S.C.E. Bessemer						Pennsylvania				%																	
												No.	Nashville Chattanooga & St. Louis																
1901 1904												%	22		33			11	11		22								
												No.	2		3			1	1		2				8	1	9		
	80 lb.	A.S.C.E. Bessemer						Carnegie Cambria				%																	
												No.	Pennsylvania Railroad Lines East.																
1901 1905		0.50	0.08	1.00	0.12			47800	48100			%	18	9					46	18	9								
												No.	2	1					5	2	1				8	3	11		
	80 lb.	A.S.C.E Bessemer						Various Mills				%																	
												No	Southern Pacific																
1895 1902								46500	49500			%	13	11	¾		12	7	45¼	8	¾	1½	¾						
												No.	17	14	1		15	9	59	10	1	2	1		94	35	129		
	80 lb.	A.S.C.E. Bessemer						Carnegie				%																	
												No	Pittsburgh & Lake Erie																
1898 1900		0.45 0.55	0.10	0.80 1.10	0.20			42000	52000			%		25				25	50										
												No.		1				1	2						2	2	4		
	80 lb.	— Sec. Bessemer						Maryland. Carnegie, Lackawanna				%																	
												No.	Rutland R.R.																
1898 1902								46500	38300			%	17	27		3		10	10	20	3	3		7					
												No.	5	8		1		3	3	6	1	1		2	9	21	30		
	80 lb. Dudley Sec. Bessemer							Carnegie				%																	
												No	Toledo & Ohio Central																
1903 1905								18500	23125			%	20					60			20								
												No	1					3			1				2	3	5		
	80 lb.	A.S.C.E. Sec. Open Hearth						Maryland				%																	
												No.	Nashville Chattanooga & St. Louis																
												%	11	11	34			22	11	11									
												No.	1	1	3			2	1	1					5	4	9		
												%																	
												No.																	
	78 lb.	N.Y.N.H. & H. Bessemer-Maryland, Lackawanna, Troy										%																	
												No.	New York New Haven & Hartford																
1896 1903.								45000	44000			%	58	8½				8½	8	17									
												No.	7	1				1	1	2					8	4	12		

Incomplete

75-72 lb. Various Section Bessemer Steel. Rolled by Various Steel Co.

As shown below Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 months compared with same period of previous year.

Record for period of ~~one year~~ ending Oct. 31 1909

48

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail.				Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
														Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		C.	P.	Mn.	Si.	S.		Freight	Passenger					Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
75 lb. A. S. C. E Sec. Bessemer								Carnegie					%																	
													No.		Central Vermont															
1899		0.40 0.50	0.10	0.70 0.90		.05		$68\frac{500}{2000}$	$57\frac{600}{2000}$				%																	
													No	2	2											2	2	4		
75 lb. A. S. C. E. Sec. Bessemer								Carnegie					%																	
													No.		Chicago & Alton.															
1905 1908													%	25				75												
													No.	1				3								4		4		
75 lb.— Sec Bessemer.							Carnegie	Cambria	Illinois	National	Tennessee Coal & Iron		%																	
													No.		Cincinnati New Orleans & Texas Pacific															
1893 1903													%	22	22			6		6	22	6	16							
													No	4	4					1	4	1	3			7	11	18		
75 lb Common Standard Harriman Lines Bessemer										Various Mills			%																	
													No		Southern Pacific															
								45250	46500				%	7	13		¾	9¼	4	26	13	7	20							
													No	10	19		1	14	6	39	19	11	30			74	75	149		
													%																	
													No.																	
													%																	
													No																	
72 lb. A S.C.E. Sec. Bessemer								Lackawanna-Scranton					%																	
													No.		Central Vermont															
1890		0.40 0.50	0.10	0.70 0.90		0.05		$68\frac{500}{2000}$	$57\frac{600}{2000}$				%																	
													No.		1												1	1		
72 lb. A.S.C.E. Sec Bessemer								Illinois Lackawanna					%																	
													No		Northern Pacific															
1897 1902		0.40 0.50	0.10	0.75 1.05	0.20			54730	52300				%	33	9	4	4	7	17	9	4	2	2	9						
													No	15	4	2	2	3	8	4	2	1	1	4		29	17	46		

Summary by Sections, Weights and Kinds of Steel. ___ Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

___ lb. ____ Section ________ Steel. Rolled by ________ Steel Co.

Record for period of ~~one year~~ 6 Months ending __ Oct. 31 ____ 1909

49

~~Year Laid~~ Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 Tons of New Rail Laid	
		~~C.~~ Wt.	~~P.~~ Kind	~~Mn.~~ of Steel	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
												Tang	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve			
P.R.R.	24020	100	Bessemer		2 Companies			Complete Records.			%	11	13		10	2	2	10	21	21	10					52		21.7
											No.	6	7		5	1	1	5	11	11	5			23	29			
A.S.C.E.	442832	"		"	7	"			"	"	%	10	3½	½	¼	14	11	29	15	4	1¼	6	4½			573		12.9
											No	58	20	2	1	81	62	168	87	25	7	36	26	370	203			
P.S.	32212	"		"	2	"			"	"	%	12	3	3	9	3	26	20½	20½	3						34		10.6
											No.	4	1	1	3	1	9	7	7	1				14	20			
N.Y.N.H. & H.	15731	"		"	1	"			"	"	%		17			33		17	33							6		3.8
											No.		1			2		1	2					3	3			
A.R.A. A.	3178	"		"	1	"			"	"	%															2		6.2
											No.								1			1		1	1			
A.R.A. B.	14466	"		"	2	"			"	"	%					12	33		33		11	11				9		6.2
											No.					1	3		3		1	1		2	7			
Dudley	149837	"		"	2	"			"	"	%	15	8	2	7	2½	9	22	16	3½	3	6	6			177		11.8
											No.	26	15	3	12	5	16	40	29	6	5	10	10	90	87			
Total	682276	"		"	13	"			"	"	%	11	5	¾	2½	11	11	26	16	5	2¼	6	4			853		12.5
											No.	94	44	6	21	91	91	221	140	43	18	48	36	503	350			
P.R.R.		100	Bessemer		1 Company.			Incomplete as to Tons Laid			%	18	13	2	2¼	4	5	8	8	26	11	2	¾			304		
											No	54	40	6	7	13	15	24	25	80	32	6	2	183	121			
N.Y.N.H. & H.		"		"	1	"		"	"	"	%	10	8		5½	17	8	15	23	5½	8					52		
											No	5	4		3	9	4	8	12	3	4			25	27			
Total		"		"	2	"		"	"	"	%	17	12	1¾	3	6¼	5	9	10½	23	10	1¾	¼			356		
											No.	59	44	6	10	22	19	32	37	83	36	6	2	208	148			
Grand Total		100	Bessemer		13 Companies.			Complete and Incomplete			%	13	7	1	2½	9½	9	21	15	10	4½	4½	3			1209		
											No.	153	88	12	31	113	110	253	177	126	54	54	38	711	498			
A.S.C.E.	38653	100	Open Hearth		3 Companies			Complete Records.			%	5				5		42		27		21				19		4.9
											No	1				1		8		5		4		19				
P.S.	11266	"		"	2	"		"	"		%	37		9		27		27								11		9.8
											No	4		1		3		3						11				
N.Y.N.H. & H.	4300	"		"	1	"		"	"		%	14								43	29	14				7		16.3
											No.	1								3	2	1		5	2			
Dudley	2274	"		"	1	"		"	"		%																	
											No.																	
Total	56493	"		"	7	"		"	"		%	16		2¾		11		30		21	5¼	14				37		6.5
											No	6		1		4		11		8	2	5		35	2			
P.R.R.		100	Open Hearth		1 Companies.			Inconplete as to Tons Laid.			%	40							20	20	20					5		
											No.	2							1	1	1			3	2			
Grand Total.		100	Open Hearth		7 Companies.			Complete and Incomplete.			%	19		2¼		10		26¼	2¼	21	7¼	12				42		
											No.	8		1		4		11	1	9	3	5		38	4			
Totals		100 lb. Rail Continued on Sheet No. 50																										

Summary by Sections, Weights and Kinds of Steel Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

--- lb. ---- Section -------- Steel. Rolled by ---------- Steel Co. Record for period of 6 Months ~~one year~~ ending Oct. 31 1909 50

~~Year Laid~~ Sec.	Tons of New Rail Laid	Specified Chemical Analysis					Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
											Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		~~C.~~ Wt.	~~P.~~ Kind of	~~Mn.~~ Steel.	Si.	S.	Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
B.R.R.		100	Nickel Bessemer		1 Company.		Incomplete as to		Tons Laid	%						17		66		17							
										No.						1		4		1				6	6		
Dudley	7940	"	Ferro Titanium Bessemer		1	"	Complete			%																	
										No.		1												1	1		1.3
Total		"		"	2	"	"	and Incomplete		%		14				15		57		14							
										No.		1				1		4		1				7	7		
Grand Totals										%																	
										No.																	
All	746709	100	All		15 Companies.		Complete			%	11	5	1	2½	11	10	26	15	6	2½	6	4					
										No.	100	45	7	21	95	91	232	140	51	20	53	36	538	353	891		11.9
"		"	"		2	"	Incomplete as to		Tons Laid	%	17	12	1½	2¾	6	5¾	9	11	23	10	1½	½					
										No.	61	44	6	10	22	20	32	42	84	38	6	2	211	156	367		
All		"	"		15	"	Complete and Incomplete.			%	13	7	1	2½	9½	9	21	14	11	4¼	4¾	3					
										No.	161	89	13	31	117	111	264	182	135	58	59	38	749	509	1258		
										%																	
										No.																	
										%																	
										No.																	
										%																	
										No.																	
										%																	
										No.																	
B&A	63678	.95	Bessemer		1 Company					%	11	2¾	1½		2¾	17	30	28		2¾	4¼						
										No.	8	2	1		2	13	22	21		2	3		36	38	74		11.7

Summary by Sections, Weights and Kind of Steel Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 Months ending Oct. 31 1909 51

---lb. ----- Section -------- Steel. Rolled by ---------- Steel Co.

~~Year Laid~~ Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		~~C.~~ Wt.	~~P.~~ Kind	~~Mn.~~ of Steel.	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
												Tang.	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve			
A.S.C.E.	568223	90	Bessemer		8 Companies. Complete Records						%	13	6	7	14	15	10	16	10	3	2	2¼	1¾			965		17.0
											No.	121	62	71	138	143	98	150	99	26	19	21	17	532	433			
A.K.A. A.	5100	"		"	1		"	"	"		%	20				60		20								5		9.8
											No.	1				3		1						5				
A.R.A. B.	28450	"		"	2		"	"	"		%	2¼	4½		4½	17	46	2¼	19	2¼	2¼					46		16.2
											No.	1	2		2	8	21	1	9	1	1			11	35			
~~Dudley~~ & A.S.C.E.	21800	"		"	1		"	"	"		%	8		8	17	17	21	17	8				4			24		11.0
											No.	2		2	4	4	5	4	2				1	12	12			
Great Northn.	40529	"		"	1		"	"	"		%		9			9	9	18	55							11		2.7
											No.		1			1	1	2	6					3	8			
Common Standard	99798	"		"	5		" Harriman Lines and Ill. Central.	"	"		%	7	4		¾	6	1½	38	31	8	1½	2¼				134		13.4
											No.	10	5		1	8	2	51	41	11	2	3		83	51			
Total	763900	"		"	16		"	"	"		%	11	6	7	12	14	11	18	13	3½	2	2	1½			1185		15.5
											No	135	70	73	145	167	127	209	157	38	22	24	18	646	539			
A.S.C.E.		"		"	2 Companies. Incomplete as to Tons Laid.						%	8½	8	¾	1¼	36	8	15	10	3	6	1	2½			294		
											No	25	23	2	4	106	23	45	29	10	17	3	7	191	103			
Grand Total		90	Bessemer		17 Companies. Complete and Incomplete.						%	11	6	5	10	19	10	17	13	3¼	2¾	1½	½			1479		
											No.	160	93	75	149	273	150	254	186	48	39	27	25	837	642			
A.S.C.E.	7661	90	Open Hearth		2 Companies. Complete Records						%	12	25	2	2	14	2	12	10	12	2	5	2			43		56.1
											No.	5	11	1	1	6	1	5	4	5	1	2	1	24	19			
A.R.A. A	66700	"	"	"	2	"			"	"	%	2		6	4	10	8½	48	13	8½						48		7.2
											No.	1		3	2	5	4	23	6	4				36	12			
A.R.A. B	32215	"	"	"	2	"			"	"	%	6	10	4		4	27	4	33	2	10					51		15.8
											No.	3	5	2		2	14	2	17	1	5			10	41			
Great Northn.	32666	"	"	"	1	"			"	"	%			6		31	13	19	6	19			6			16		4.9
											No			1		5	2	3	1	3			1	12	4			
Common Standard	8992	"	"	"	3	"	Harriman Lines and Ill. Central		"	"	%	16					11	6	44	11	6	6				18		20.0
											No	3					2	1	8	2	1	1		7	11			
D.L.&W.	26822	"	"	"	1	"			"	"	%	22	48					7½	2½	2½	15	2½				40		14.9
											No	9	19					3	1	1	6	1		14	26			
Total	175056	"	"	"	10	"					%	10	16	3	1¼	9	10	17	17	8	6	1¾	1			216		12.3
											No.	21	35	7	3	18	23	37	37	16	13	4	2	103	113			
A.S.C.E.		90	Open Hearth		1 Company Incomplete as to Tons Laid						%	17	45	1½	3	1½	15		7		4		6			69		
											No	12	31	1	2	1	10		5		3		4	14	55			
Grand Total		90	Open Hearth		11 Companies Complete and Incomplete.						%	11	23	3	1¾	7	11	13	15	6	6	1¼	2			285		
											No	33	66	8	5	19	33	37	42	16	16	4	6	117	168			
		90 lb. Rail continued on Sheet No. 52									%																	
											No																	

Summary by Sections, Weights and Kinds of Steel Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

52

--- lb ---- Section ---------- Steel. Rolled by ---------- Steel Co. Record for period of ~~one year~~ 6 Months ending *Oct. 31* 1909

Year Laid *Sec.*	Tons of New Rail Laid	Specified Chemical Analysis C. *Wt.*	P. *Kind*	Mn. *of Steel*	Si.	S.		Maximum Axle Load of Locomotives Freight	Passenger	Approximate Gross Tons over Rail.		Kind of Failure: Broken Tang.	Broken Curve	Flow of Metal Tang	Flow of Metal Curve	Crushed Head Tang	Crushed Head Curv.	Split Head Tang.	Split Head Curve	Split Web Tang.	Split Web Curve	Broken Base Tang	Broken Base Curve	Total Tang	Total Curve	Grand Total	Failures per 10,000 tons of New Rail laid Last Year	Present Year
A.S.C.E	*5014*	*90*	*Chrome*	*Nickel*	*1 Company.*			*Complete Records*			%	*8*	*38*				*¾*	*7½*	*45*	*¼*	*½*							
											No.	*28*	*134*				*3*	*27*	*155*	*1*	*2*			*56*	*294*	*350*		*698.0*
"		*"*	*"*	*"*	*1*	*"*		*Incomplete as to Tons Laid.*			%	*16½*	*16½*						*67*									
											No	*1*	*1*						*4*					*1*	*5*	*6*		
Total		*"*	*"*	*"*	*2*	*"*		*Complete and Incomplete.*			%	*8*	*38*				*1*	*8*	*44*	*¼*	*¾*							
											No.	*29*	*135*				*3*	*27*	*159*	*1*	*2*			*57*	*299*	*356*		
											%																	
											No.																	
Grand Totals											%																	
											No.																	
All	*943970*	*90*	*All*		*19 Companies.*			*Complete Records.*			%	*10*	*14*	*5*	*8*	*11*	*9*	*15*	*20*	*3*	*2*	*1¾*	*1¼*			*		*
											No.	*184*	*239*	*80*	*148*	*185*	*153*	*273*	*349*	*55*	*37*	*28*	*20*	*805*	*946*	*1751*		*18.5*
"		*"*	*"*		*2*	*"*		*Incomplete as to Tons Laid.*			%	*10*	*15*	*1*	*2*	*29*	*9*	*12*	*10*	*3*	*5*	*1*	*3*					
											No	*38*	*55*	*3*	*6*	*107*	*33*	*45*	*38*	*10*	*20*	*3*	*11*	*206*	*163*	*369*		
All		*90*	*All*		*20 Companies.*			*Complete and Incomplete.*			%	*10¼*	*14*	*4*	*7*	*14*	*9*	*15*	*18*	*3*	*2¾*	*1½*	*1½*					
											No.	*222*	*294*	*83*	*154*	*292*	*186*	*318*	*387*	*65*	*57*	*31*	*31*	*1011*	*1109*	*2120*		
											%																	
											No.																	
											%																	
											No.																	
											%																	
											No.						** Including*	*Chrome*	*Nickel*							*1751*		*18.5*
											%																	
											No.						*Excluding*		*"*	*"*						*1395*		*14.9*

Summary by Sections Weights and Kind of Steel Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

Record for period of ~~one year~~ ending Oct. 31 1909 53

___ lb. _____ Section __________ Steel. Rolled by __________ Steel Co.

Year Laid Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail.		Kind of Failure: Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total		Grand Total	Failures per 10 000 tons of New Rail laid	
		~~C.~~ Wt.	~~P.~~ Kind of Steel	~~Mn~~	Si.	S.		Freight	Passenger			Tang	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
P.R.R.	124368	85	Bessemer		4 Companies.			Complete Records			%	16	4			16	5	29	17	8		4	1					
											No.	15	4			15	5	27	16	7		4	1	68	26	94		76
A.S.C.E.	2138851	"	"		19	"		"	"		%	11	5	2	2	20	19	16	11	4	1¾	6	2¼					
											No.	295	127	54	59	529	497	455	280	95	45	145	67	1573	1075	2648		12.4
P.S.	21800	"	"		2	"		"	"		%	2	1		7	7	43	7	23	3	7							
											No.	2	1		7	7	46	8	25	3	8			20	87	107		49.1
A. A.R.A.	16932	"	"		1	"		"	"		%			9		9	9	27½	9	18½	9	9						
											No.			1		1	1	3	1	2	1	1		8	3	11		6.5
C.B.&Q.	363870	"	"		1	"		"	"		%	4	8½		1¼	17½	24	22	13	2¾	1¾	3¼	2					
											No	12	25		4	53	72	66	40	8	5	11	6	150	152	302		8.3
Great Northin.	102961	"	"		1	"		"	"		%	1½	1½	2¼	1½	16	33	20	11	¾	¾	11	¾					
											No	2	2	3	2	22	46	27	15	1	1	15	1	70	67	137		13.3
Total	2768782	"	"		24	"		"	"		%	10	5	1¾	2¼	19	20	18	11	3½	1¾	5½	2¼					
											No	326	159	58	72	627	667	586	377	116	60	176	75	1889	1410	3299		11.9
P.R.R.		85	Bessemer		1 Company.			Incomplete as to Tons Laid			%	11	17	1½		7½	10	11	13	7	6	4	12					
											No	31	50	4		21	30	33	42	20	17	10	34	119	173	292		
A.S.C.E.		"	"		2	"		"	" "	"	%					11	22½	33		22½	11							
											No					1	2	3		2	1			6	3	9		
		"	"		1	"		"	" "	" & Sec.	%	22	33					11½	11½	11	11							
											No.	2	3					1	1	1	1			4	5	9		
Total		"	"		3	"		Incomplete			%	10½	17	1¼		7	11	12	14	7	6	3¼	11					
											No.	33	53	4		22	32	37	43	23	19	10	34	129	181	310		
Grand Total		85	Bessemer		25 Companies.			Complete and Incomplete			%	10	6	1¾	2	18	20	17	11	4	2¼	5	3					
											No	359	212	62	72	649	699	623	420	139	79	186	109	2018	1591	3609		
A.S.C.E.	81723	85	Open Hearth		7 Companies.			Complete			%	13	15	10	12	13	10	8	10	6	2	2						
											No	7	8	5	6	7	5	4	5	3	1	1		27	25	52		6.4
P.S.	8415	"	"	"	2	"		"			%	17		17	17			17	16		16							
											No	1		1	1			1	1		1			3	3	6		7.0
C.B.&Q.	10000	"	"	"	1	"		"			%						12½	25	12½	25		25						
											No						1	2	1	2		2		6	2	8		8
Great Northin.	10043	"	"	"	1	"		"			%	7	3			13	44	17	3	3			10					
											No	2	1			4	13	5	1	1			3	12	18	30		30.0
Total	110181	"	"	"	10	"		"			%	10	9	6	7	13	20	13	8	6	2	3	3					
											No.	10	9	6	7	11	19	12	8	6	2	3	3	48	48	96		8.8
		"	"	"	1	"		Incomplete as to Tons Laid & Sec.			%																	
											No	2								1				3		3		
Grand Total		85	Open Hearth		11 Companies.			Complete and Incomplete.			%	12¼	9	6	7	11¼	19¼	12¼	8	7	2	3	3					
											No.	12	9	6	7	11	19	12	8	7	2	3	3	51	48	99		
Totals		85 lb. Rail continued on Sheet No. 54																										

Summary by Sections, Weights and Kinds of Steel Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

---lb.---- Section ---------Steel. Rolled by---------- Steel Co. Record for period of ~~one year~~ 6 Months ending Oct 31 1909 54

Year Laid Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		~~C.~~ Wt.	~~P.~~ Kind of Steel	~~Mn.~~	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
A.S.C.E.	1655	85	Nickel		1 Company			Complete Record			%																	
											No.					3								3		3		18.1
											%																	
											No.																	
Grand Totals											%																	
											No.																	
All	2880618	85	All		24 Companies.			Complete			%	10	5	2	2½	19	20	17	11	4	2	5	2½					
											No.	336	168	64	79	641	686	598	385	122	62	179	78	1940	1458	3398		11.1
"	"		"		3	"		Incomplete			%	11	18	1¼		7	10	12	13	7¾	6	3	11					
											No.	35	53	4		22	32	37	43	24	19	10	34	132	181	313		
All	"		All		25 Companies.			Complete and Incomplete.			%	10	6	1¾	2	18	19	17	12	4	2¼	5	3					
											No.	371	221	68	79	663	718	635	428	146	81	189	112	2072	1639	3711		

Summary by Sections, Weights and Kind of Steel. Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

___ lb. ____ Section ________ Steel. Rolled by ________ Steel Co. Record for period of 6 Months ~~one year~~ ending Oct. 31 1909 55

Year Laid Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		~~C.~~ Wt.	~~P.~~ Kind of	~~Mn.~~ Steel	Si.	S.		Freight	Passenger			Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total			Last Year	Present Year
												Tang.	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve			
ASCE	1357537	80	Bessemer		24 Companies. Complete Records						%	9	2¼	½	¾	21	6	40	13	4	1	2	½					
											No.	135	34	7	11	302	84	574	191	65	14	24	8	1107	342	1449		10.7
~~NY.NH B.H.~~	17565	"	"		1		"	"	"	A.S.C.E Sec	%		20				10		10	20	10	30						
											No		2				1		1	2	1	3		5	5	10		5.6
Dudley	206857	"	"		4		"	"	"		%	21	18			9	6	18	20	7	1							
											No.	19	16			8	5	16	18	6	1			49	40	89		4.3
Great Northin	52532	"	"		1		"	"	"		%	10	1			14	5	13	2	3		48	4					
											No.	13	1			19	6	17	2	4		63	5	116	14	130		24.7
~~Common Standard~~	27491	"	"		1		"	" Harriman Lines	"	A.S.C.E Sec	%		4¼			30½	30½	4¼	22	4¼			4¼					
											No.		1			7	7	1	5	1			1	9	14	23		8.3
ASCE [illegible]	17388	"	"		1		"	"	"		%	8	4			6	26	8	30			10	8					
											No.	4	2			3	13	4	15			5	4	16	34	50		28.8
Special 540	2500	"	"		1		"	"	"		%																	
											No.	1												1		1		4.0
Total	1681870	"	"		30		"	"	"		%	10	3¼	½	¾	19	7	35	13	4½	1	5	1					
											No.	172	56	7	11	339	116	612	232	78	16	95	18	1303	449	1752		10.4
ASCE		80	Bessemer		7 Companies. Incomplete as to Tons Laid.						%	25	14	1		7	4½	28	4	10	3¾	1¼	1½					
											No.	99	57	4		29	18	110	17	41	15	6	7	289	114	403		
Dudley		"	"		1	"		"	"	" "	%	20					60			20								
											No.	1					3			1				2	3	5		
		"	"		3	"		"	"	" " 8 Sec	%	5	2½	½	½	7	1¾	69	12	½	¼	½	½					
											No.	17	9	2	2	27	7	256	46	2	1	2	2	306	67	373		
Total		"	"		11	"		Incomplete.			%	15	8	¾	¼	7	3¾	47	8	6	2	1	1¼					
											No.	117	66	6	2	56	28	366	63	44	16	8	9	597	184	781		
Grand Total		"	"		36 Companies. Complete and Incomplete.						%	11	4¾	½	½	15	6	39	12	5	1¼	4	1					
											No	289	122	13	13	395	144	978	295	122	32	103	27	1900	633	2533		
ASCE	231209	80	Open Hearth		8 Companies			Complete			%	10	5	2	5	25	2½	17½	7	10	10	5¼	¾					
											No.	30	16	6	15	77	8	55	21	30	30	17	2	215	92	307		13.3
NY, NH &H	975	"	"	"	1			"			%																	
											No.	1												1		1		10.3
Total	232184	"	"	"	9			"			%	10	5	2	5	25	2½	17½	7	10	10	5¼	¾					
											No.	31	16	6	15	77	8	55	21	30	30	17	2	216	92	308		13.3
ASCE		80	Open Hearth		1 Company			Incomplete as to Tons Laid.			%	11½	11½	33			22	11	11									
											No.	1	1	3			2	1	1					5	4	9		
Grand Total		80	"	"	9 Companies			Complete and Incomplete.			%	10	5	3	5	24	3	18	7	9½	9½	5¼	¾					
											No.	32	17	9	15	77	10	56	22	30	30	17	2	221	96	317		
		80 lb. Rail continued on Sheet No. 56									%																	
											No.																	

Summary by Sections, Weights & Kinds of Steel Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 Months ending Oct. 31 1909 56

--- lb. ---- Section --------- Steel. Rolled by ---------- Steel Co.

Year Laid Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10 000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		~~C~~ Wt.	~~P~~ Kind of Steel	~~Mn~~	Si.	S.		Freight	Passenger				Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
Grand Totals												%																	
												No.																	
All	1914054	80	AN		32 Companies.			Complete Records				%	11	3½	¾	1¼	20	6	32	12	5	2¼	5¼	1					
												No.	203	72	13	26	416	124	667	253	108	46	112	20	1519	541	2060		1024
″			″		11	″		Incomplete		″		%	15	8½	1¼	¼	7	3¾	47	8	5½	1½	1	1¼					
												No.	118	67	9	2	56	30	367	64	44	16	8	9	602	188	790		
All		80	AN		36 Companies.			Complete and Incomplete				%	11	4½	¾	1	17	5½	36	11	5½	2¼	4½	1					
												No.	321	139	22	28	472	154	1034	317	152	62	120	29	2121	729	2850		
												%																	
												No.																	
												%																	
												No.																	
NY NH & H.	17957	78	Bessemer		1 Company.			Complete Records				%		40						20		40							
												No.		2						1		2				5	5		2.8
″		″		″	1	″		Incomplete as to Tons Laid				%	58	8½				8½	8	17									
												No.	7	1				1	1	2					8	4	12		
Total		78		″	1	″		Complete & Incomplete				%	41	17½				6	6	17½		12							
												No.	7	3				1	1	3		2			8	9	17		

Summary by Sections, Weights and Kinds of Steel. Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

___ lb. _____ Section ________ Steel. Rolled by __________ Steel Co.

Record for period of ~~one year~~ ending __Oct. 31___ 1909 57

Year Laid Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Approximate Gross Tons over Rail.			Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
		~~C.~~ Wt.	P. Kind of Steel	Mn.	Si.	S.		Freight	Passenger				Tang	Curve	Tang	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve.	Tang	Curve	Tang	Curve		Last Year	Present Year
ASC.E	407808	75	Bessemer		7 Companies.			Complete Records				%	13	12	¼	¾	7	17	13½	9¼	9¼	9	6	3					
												No	35	33	1	2	19	46	36	26	26	24	15	7	132	138	270		6.7
Common Stand.	135971	″		″	9 (Harriman Lines)	″		″	″			%	8	22		2¼	16	12¾	14	10	4	10	¾	¼					
												No	34	96		10	69	55	63	43	19	43	3	1	188	248	436		82.1
B&M.	41263	″		″	2	″		″	″			%	11	45								22	11	11					
												No.	1	4								2	1	1	2	7	9		2.2
C&O	26957	″		″	1	″		″	″			%				67				33									
												No				2				1						3	3		1.1
Total	611999	″		″	19	″		″	″			%	10	18		2	12	14	14	10	6¼	9¾	2¾	1¼					
												No.	70	133	1	14	88	101	99	70	45	69	19	9	322	396	718		11.7
ASCE		75	Bessemer.		2 Companies			Incomplete as to		Tons Laid.		%	37½	25			37½												
												No	3	2			3								6	2	8		
Common Stand		″		″	1 (Harriman Lines)	″		″	″	″ ″		%	7	13		¾	9¼	4	26	13	7	20							
												No	10	19		1	14	6	39	19	11	30			74	75	149		
		″		″	1			″	″	″ ″ & Sec.		%	22	22			6		6	22	6	16							
												No	4	4			1		1	4	1	3			7	11	18		
Total		″		″	4			″	″	″ ″ ″		%	9¾	14		½	10¼	3½	23	13	7	19							
												No.	17	25		1	18	6	40	23	12	33			87	88	175		
Grand Total		75	Bessemer		22 Companies.			Complete and Incomplete				%	10	18		2	12	12	15	10½	6	11½	2	1					
												No.	87	158	1	15	106	107	139	93	57	102	19	9	409	484	893		
ASC.E	37491	75	Open Hearth		1 Company.			Complete				%	67	13							13		7						
												No.	10	2							2		1		13	2	15		4.0
Grand Totals												%																	
												No.																	
All	649490	75	All		19 Companies.			Complete				%	11	19		2	12	14	13	10	6	9	2¾	1¼					
												No	80	135	1	14	88	101	99	70	47	69	20	9	335	398	733		11.3
″		″	″		4	″		Incomplete				%	9¾	14		½	10¼	3½	23	13	7	19							
												No	17	25		1	18	6	40	23	12	33			87	88	175		
Grand Total		″	″		22	″		Complete and Incomplete				%	10¾	18		1¾	12	12	15	10	6½	11	2	1					
												No	97	160	1	15	106	107	139	93	59	102	20	9	422	486	908		

Summary by Section, Weights and Kinds of Steel. Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

Record for period of ~~one year~~ ending Oct. 31 1909 58

lb. Section Steel. Rolled by Steel Co.

Lines	Year Laid Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
													Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
			C. Wt.	P. Kind of Steel	Mn.	Si.	S.		Freight	Passenger			Tang	Curve	Tang.	Curve	Tang	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
1	ASCE	26684	72	Bessemer		1 Company.			Complete Records.			%			29			14	29	14	14								
												No.			2			1	2	1	1				5	2	7		2.6
2	Special 7201	202665	″		″	1	″		″	″		%	35	11			11	1¾	27	9	1¾	1¾	1¾						
												No	19	6			6	1	15	5	1	1	1		42	13	55		2.7
3	Total	229349	″		″	2	″		″	″		%	31	10	3		10	3	27	10	3	1½	1½						
												No.	19	6	2		6	2	17	6	2	1	1		47	15	62		2.7
4	ASCE		72	Bessemer		2 Companies.			Incomplete as to Tons Laid.			%	32	11	4	4	6	17	9	4	2	2	9						
												No.	15	5	2	2	3	8	4	2	1	1	4		29	18	47		
5	Grand Total		72	Bessemer		3 Companies.			Complete and Incomplete.			%	32	10	3¾	2	8	9	19	7	2¾	2	4½						
												No.	34	11	4	2	9	10	21	8	3	2	5		76	33	109		

Summary by Sections, Weights and Kinds of Steel Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

---lb. ---- Section ---------- Steel. Rolled by---------- Steel Co.

Record for period of ~~one year~~ 6 Months ending --Oct. 31--- 1909 59

Year Laid Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure: Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total		Grand Total	Failures per 10,000 tons of New Rail laid	
		~~C.~~ Wt.	~~P.~~ Kind of Steel	~~Mn.~~	Si.	S.		Freight	Passenger			Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve		Last Year	Present Year
All	746709	100	All		15 Companies.			Complete Records			%	11	5	1	2½	11	10	26	15	6	2½	6	4					
											No.	100	45	7	21	95	91	232	140	51	20	53	36	538	353	891		11.9
"	63678	95	"		1	"		"	"		%	11	2¾	1½		2¾	17	30	28		2¾	4¼						
											No.	8	2	1		2	13	22	21		2	3		36	38	74		11.6
"	943970	90	"		19	"		"	"		%	10	14	5	8	11	9	15	20	3	2	1¾	1¼			*		*
											No.	184	239	80	148	185	153	273	349	55	37	28	20	805	946	1751		18.5
"	2880618	85	"		24	"		"	"		%	10	5	2	2½	19	20	17	11	4	2	5	2½					
											No.	336	168	64	79	641	686	598	385	122	62	179	78	1940	1458	3398		11.1
"	1914054	80	"		32	"		"	"		%	11	3½	¾	1¼	20	6	32	12	5	2¼	5¼	1					
											No.	203	72	13	26	416	124	667	253	108	46	112	20	1519	541	2060		10.2
"	17957	78	"		1	"		"	"		%		40						20		40							
											No.		2						1		2				5	5		2.8
"	649490	75	"		19	"		"	"		%	11	9	0	2	12	14	13	10	6	9	2¾	1¼					
											No.	80	135	1	14	88	101	99	70	47	69	20	9	335	398	733		11.3
"	229349	72	"		2	"		"	"		%	31	10	3		10	3	27	10	3	1½	1½						
											No.	19	6	2		6	2	17	6	2	1	1		47	15	62		2.7
Total	7445825	All	All		58 Companies			"	"		%	10	7	2	3	16	13	21	14	4½	3	4½	2					
											No.	930	669	168	288	1433	1170	1908	1225	385	239	396	163	5220	3754	8974		1205
All		100	"		2 Companies			Incomplete Records			%	17	12	1½	2¾	6	5¾	9	11	23	10	1½	½					
											No.	61	44	6	10	22	20	32	42	84	38	6	2	211	156	367		
"		90	"		2	"	10 of these Companies send complete reports also	"		"	%	10	15	1	2	29	9	12	10	3	5	1	3					
											No.	38	55	3	6	107	33	45	38	10	20	3	11	206	163	369		
"		85	"		3	"		"		"	%	11	18	1¼		7	10	12	13	7¾	6	3	11					
											No.	35	53	4		22	32	37	43	24	19	10	34	132	181	313		
"		80	"		11	"		"		"	%	15	8½	1¼	¼	7	3¾	47	8	5½	1½	1	1¼					
											No.	118	67	9	2	56	30	367	64	44	16	8	9	602	188	790		
"		78	"		1	"		"		"	%	58	8½				8½	8	17									
											No.	7	1				1	1	2					8	4	12		
"		75	"		4	"		"		"	%	9¾	14		½	10¼	3½	23	13	7	19							
											No.	17	25		1	18	6	40	23	12	33			87	88	175		
"		72	"		2	"		"		"	%	32	11	4	4	6	17	9	4	2	2	9						
											No.	15	5	2	2	3	8	4	2	1	1	4		29	18	47		
Total		All	All		15 Companies.			"		"	%	15	12	1¼	1	11	6¼	25	10	8½	6	1½	2½					
											No.	291	250	24	21	228	130	526	214	115	127	31	56	1275	798	2073		
Grand Total		All	All		63 Companies.			Complete and Incomplete.			%	11	8	1¾	2¾	15	12	22	13	5	3½	4	2					
											No.	1221	919	192	309	1661	1300	2434	1439	560	366	427	219	6495	4552	11047		
											%							*	Including		Chrome	Nickel				1751		18.5
											No.								Excluding		"		"			1395		14.9

DATA FOR DIAGRAM 1
The upper figures give Failures per 10000
Tons of New Rail Laid.

Comparison between different Weights of Rail. Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

Record for period of ~~one year~~ ending Oct. 31 1909 60

lb. Section Bessemer Steel. Rolled by Steel Co.

~~Year Laid~~ Wt.	Tons of New Rail Laid	Specified Chemical Analysis ~~C.~~ Kind of Steel	P.	Mn.	Si.	S.		Maximum Axle Load of Locomotives. Freight	Passenger	Approximate Gross Tons over Rail	...
100	682276	Bessemer				13 Companies					
Balto & Ohio 81522 Tons – Boston & Albany 29230 – Chesapeake & Ohio 19070											
Michigan Central 143563 – New York Cent. & Hudson Riv. 120607 – N.Y. N. Haven & H. 15731											
95	63678	Bessemer				Boston & Albany					
90	763900	Bessemer				16 Companies					
Balto. & Ohio 27550 Tons – Balto. & Ohio S.W. 6000 – Buffalo, Rochester & Pgh. 31800.											
Del. Lackawanna & West'n. 41026 – Galveston, Harrisburg & San Antonio 7252.											
Pitts. & Lake Erie 35366 – Phila. & Reading 159849 – Texas & N. Orleans 296											
85	2768782	Bessemer				24 Companies					
Atchison, Topeka & Santa Fe 73122 Tons – Atlantic Coast Line 69520.											
Bangor & Aroostook 14362 – Boston & Maine 56369 – Ches. & Ohio 51471											
Evansville & Terre Haute 4705 – Ft. Worth & Denver City 11535											
Norfolk & Western 213000 – Nor. Pacific 198756 – Pa. Lines East 12556											
Southern Ry. 27757 – Vandalia 18821.											

	Kind of Failure																Grand Total	Failures per 10,000 tons of New Rail laid	
	Broken		~~Flow of Metal~~		Head ~~Crushed Head~~		~~Split Head~~		Split Web		Broken Base		Total						
	Tang	Curve	~~Tang~~	~~Curve~~	Tang	Curve	~~Tang~~	~~Curve~~	Tang.	Curve	Tang	Curve	Tang	Curve				Last Year	Present Year
%	1.4	0.6			4.7	3.7			0.6	0.3	0.7	0.5	7.4	5.1			12.5		
No.	94	44			318	252			43	18	48	36	503	350			853		
%																			
No	Chgo. Burlington & Quincy 2055 – Cumberland Valley. 12158 – Lake Shore & Mich. Sou. 88344																		
%																			
No.	Penn'a R.R. East 22348 – Penn'a. Lines West 65257 – Pitts. & L. Erie 566 – Rock Island Lines 825.																		
%																			
No																			
%	1.3	0.3			3.9	5.4				0.3	0.5		5.7	6.0			11.7		
No.	8	2			25	34				2	3		36	38			74		
%																			
No.																			
%	1.8	0.9			5.9	5.6			0.5	0.3	0.3	0.2	8.5	7.0			15.5		
No.	135	70			449	429			38	22	24	18	646	539			1185		
%																			
No	Cent. R.R. of N. Jersey 53085 – Chgo. & Nor'west'n. 174301 – Cleve. Cin. Chgo. & St. Lou. 88986.																		
%																			
No.	Great Nor. 40529 – Hocking Valley 5610 – Illinois Central 2473 – Oregon Short Line 2598																		
%																			
No.	Union Pacific 87179.																		
%																			
No.																			
%	1.2	0.6			4.6	4.1			0.4	0.2	0.6	0.2	6.8	5.1			11.9		
No.	326	159			1271	1116			116	60	176	65	1889	1410			3299		
%																			
No	Balto. Chesapeake & Atlantic 674 – Balto. & Ohio 367511. – Balto. & Ohio S.W. 93479.																		
%																			
No	Chgo. & East'n. Illinois 25112 – Chgo. Burlington & Quincy 363870 – Cumb'd. Val. 5008																		
%																			
No.	Grand Rapids & Indiana 11600 – Great Northern 102961 – Illinois Central 317125																		
%																			
No.	Pa. Lines West 571292 – Rock Island Lines 142006 – St. Louis & S. Francisco 16170																		
%																			
No.																			

DATA FOR DIAGRAM 1

The upper figures give Failures per 10000 Tons of New Rail Laid.

Comparison between different Weights of Rail _ Railroad.

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 Months ending __ Oct. 31 ___ 1908 _ 61

__ lb. ____ Section Bessemer __ Steel. Rolled by __________ Steel Co.

~~Year Laid~~ Wt.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		~~C.~~ Kind of Steel	~~P.~~	~~Mn.~~	Si.	S.		Freight	Passenger			Broken		~~Flow of Metal~~		~~Crushed~~ Head		~~Split Head~~		Split Web		Broken Base		Total			Last Year	Present Year
												Tang.	Curve	~~Tang.~~	~~Curve~~	Tang	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	Tang	Curve	Tang	Curve			
80	1681870	Bessemer				30 Companies					%	1.0	0.3			5.7	2.2			0.4	0.1	0.6	0.1	7.7	2.7	10.4		
											No.	172	56			958	359			78	16	95	18	1303	449	1752		
											%																	
Cent. of N. England 3787 Tons - Chgo. & East'n. Illinois 43643											No.	Chgo. & Nor'west'n. 85975 - Cleve. Cin. Chgo. & St. Louis. 146594 - Del. Lack'wna. & West'n																
											%																	
38799 - Evansville & T. Haute 5473 - Galveston, Harrisburg &											No.	San Antonio 48064 - Grand Trunk 138398 - Great North'n. 52532 - Hocking Val. 5640																
											%																	
Houston & Texas Cent. 37728 - Lake Shore & Mich. South'n. 162163											No.	Lake Shore & Ishpeming 2500 - Lehigh & Hudson 8474 - Louisiana Western 9994																
											%																	
Marquette & Sou. East'n. 1941 - Memissing R.R. 2083											No.	Michigan Central 42776 - N. York Cent. & Hudson Riv. 191905 - N. York, N. Hav. & Hart. 17565																
											%																	
Oregon R.R. & Nav. Co. 27491 - Oregon Short Line 42501											No.	Pitts. & Lake Erie 20415 - Rock Island Lines 309741 - St. Joseph & Grand Island 9159																
											%																	
South'n. Pacific 47311 - Southern Ry. 42113											No.	Temiskaming & Nor. Ontario 23940 - Toledo & Ohio Central 8312 - Union Pacific 104853																
											%																	
											No.																	
78	17957	Bessemer			N. York, N. Haven & Hartford.						%		1.1				0.6				1.1				2.8	2.8		
											No.		2				1				2				5	5		
											%																	
											No.																	
75	611999	Bessemer				19 Companies					%	1.1	2.2			3.1	3.0			0.8	1.1	0.3	0.1	5.3	6.4	11.7		
											No.	70	133			188	185			45	69	19	9	322	396	718		
											%																	
Boston & Maine 133550 Tons - Chesapeake & Ohio 26957											No.	Ft. Worth & Denver City 25768 - Galveston, Harrisburg & San Antonio 31168																
											%																	
Houston & Texas Central 15699 - Illinois Central 136772											No	Louisiana & Western 2634 - Maine Central 37063 - Morgans Louisiana & Texas R.R. 6827																
											%																	
Norfolk & West'n. 6000 - Oregon R.R. & Nav. Co. 24919 - Oregon Short											No	Line 2344 - St. Louis & Grand Island 1526 - St. Louis & San Francisco 46900																
											%																	
Somerset Ry. 4200 - Southern Ry. 29023 - Sou. Pacific 32511											No	Toledo, St. Louis & Western 29795 - Union Pacific 18343.																
											%																	
											No.																	
72	229349	Bessemer				2 Companies					%	0.8	0.3			1.05	0.35			0.1	0.05	0.05		2.0	0.7	2.7		
											No.	19	6			25	8			2	1	1		47	15	62		
											%																	
Chgo. & North Western 202665 - Tons. - Nor. Pacific 26684											No.																	

DATA FOR DIAGRAM 2

The upper figures give Failures per 10,000
Tons of New Rail Laid.

Comparison between different Weights of Rail. Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

___lb.____ Section Open Hearth Steel. Rolled by__________ Steel Co.

Record for period of 6 Months ~~one year~~ ending __Oct. 31____ 1909_ 62

~~Year Laid~~ Wt.	Tons of New Rail Laid	Specified Chemical Analysis				Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
										Broken		~~Flow of Metal~~		~~Crushed~~ Head		~~Split Head~~		Split Web		Broken Base		Total				
		~~C.~~ ~~P.~~ ~~Mn.~~ Kind of Steel.	Si.	S.		Freight	Passenger			Tang	Curve	~~Tang.~~	~~Curve~~	Tang	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
									%	1.1				28				1.4	0.3	0.9		6.2	0.3	6.5		
100	56493	Open Hearth		7 Companies.					No.	6				16				8	2	5		35	2	37		
									%																	
Grand Trunk 34382 Tons – Lehigh & Hudson 460 – Michigan Central 3811									No.	N.York Central & Hudson Riv. 2274 – N.York, N.Haven & Hartford 4300 – Penna. Lines E. 1352																
									%																	
Penna. Lines West 9914.									No.																	
									%																	
									No.																	
									%	1.2	2.0			3.5	3.6			1.0	0.7	0.2	0.1	5.9	6.4	12.3		
90	175056	Open Hearth		10 Companies.					No.	21	35			62	63			16	13	4	2	103	113	216		
									%																	
Balto. & Ohio 10600 Tons – Buffalo, Rochester & Pitts. 1500 – Cent'l. R.R. of N. Jersey 6161									No.	Chgo. Burlington & Quincy 64700 – Delaware, Lackawanna & Western 26822																
									%																	
Galveston, Harrisburg & San Antonio 3202 – Great Northern 32666									No.	Illinois Central 2473 – North'n. Pacific 23615 – South'n. Pacific 3317.																
									%																	
									No.																	
									%	0.9	0.8			2.6	3.1			0.6	0.2	0.3	0.3	4.4	4.4	8.8		
85	110181	Open Hearth		10 Companies					No.	10	9			29	34			6	2	3	3	48	48	96		
									%																	
Boston & Maine 8220 Tons – Chgo. Burlington & Quincy 10000									No.	Great Northern 10043 – Illinois Central 11833 – Norfolk & Western 16000																
									%																	
Penna. Lines East 2494 – Penna. Lines West 6401 – Rock Island Lines 1749									No.	St. Louis & San Francisco 10000 – Southern Ry. 33441																
									%																	
									No.																	
									%	1.3	0.7			6.0	1.9			1.3	1.3	0.7	0.1	9.3	4.0	13.3		
80	232184	Open Hearth		9 Companies.					No	31	16			138	44			30	30	17	2	216	92	308		
									%																	
Central R.R. of N. England 1235 Tons – Cleve. Cin'ti. Chgo. & St. Louis 1050									No.	Galveston, Harrisburg & San Antonio 7007 – Grand Trunk 26974 – Louisville & Nashville 19726																
									%																	
Nashville, Chattanooga & St. Louis 16261 – N.York, N.Haven & Hartford 975									No	Rock Island Lines 123 – Southern Ry. 58833																
									%																	
									No.																	
									%	2.7	0.5							0.5		0.3		3.5	0.5	4.0		
75	37491	Open Hearth		Southern Ry.					No.	10	2							2		1		13	2	15		

DATA FOR DIAGRAM 3

The upper figures give Failures per 10000 Tons of New Rail Laid.

Comparison between different Sections of Rail Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

---lb.----- Section Bessemer - Steel. Rolled by---------- Steel Co. Record for period of ~~one year~~ ending --Oct 31---1909- 63

~~Year Laid~~ Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure															Failures per 10,000 tons of New Rail laid	
												Broken		~~Flow of Metal~~		~~Crushed~~ Head		~~Split Head~~		Split Web		Broken Base		Total		Grand Total		
		~~C.~~ Wt.	~~P.~~ Kind of Steel	~~Mn.~~	Si.	S.		Freight	Passenger			Tang.	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
P.R.R.	24020	100	Bessemer.			2 Companies.					%	2.5	2.9			2.5	7.1			4.6	21			9.6	12.1	21.7		
											No.	6	7			6	17			11	5			23	29	52		
Cumberland Valley 12158 Tons — Penn'a. R.R. Lines East 11862											%																	
											No.																	
A.S.C.E.	442832	100	Bessemer.			7 Companies.					%	1.3	0.5			5.7	3.3			0.6	0.1	0.8	0.6	8.4	4.5	12.9		
											No.	58	20			251	150			25	7	36	26	370	203	573		
Balto. & Ohio 67622 Tons — Chesapeake & Ohio 19070 — Chgo. Burlington & Quincy 2055 Lake Shore & Mich. Sou. 168344 — Michigan Cent'l. 143563 — Pa. Lines West 41353 — Rock Island Lines 825											%																	
											No.																	
P.S.	32212	100	Bessemer.			2 Companies.					%	1.3	0.3			2.8	5.9			0.3				4.4	6.2	10.6		
											No.	4	1			9	19			1				14	20	34		
Penn'a. R.R. Lines East 10486 + Penn'a. Lines West 21726											%																	
											No.																	
N.Y.N.H. & H.	15731	100	Bessemer.			N. York, N. Haven & Hartford					%		0.6			1.9	1.3							1.9	1.9	3.8		
											No.		1			3	2							3	3	6		
A.R.A.^{A}	3178	100	Bessemer.			Penn'a. Lines West					%						3.1					3.1		3.1	3.1	6.2		
											No.						1					1		1	1	2		
A.R.A.^{B}	14466	100	Bessemer			2 Companies.					%					0.7	4.1				0.7	0.7		1.4	4.8	6.2		
											No.					1	6				1			2	7	9		
Balto. & Ohio 13900 Tons — Pittsburgh & Lake Erie 566.											%																	
											No.																	
Dudley	149837	100	Bessemer			2 Companies.					%	1.7	1.0			3.2	3.8			0.4	0.3	0.7	0.7	6.0	5.8	11.8		
											No.	26	15			48	57			6	5	10	10	90	87	177		
Boston & Albany 29230 Tons + N. York Central & Hudson River 120607											%																	
											No.																	
											%																	
											No.																	
All	682276	100	Bessemer			13 Companies.					%	1.4	0.6			4.7	3.6			0.6	0.3	0.7	0.5	7.4	5.1	12.5		
											No.	94	44			318	252			43	18	48	36	503	350	853		
											%																	
											No.																	
B. & A.	63678	95	Bessemer			Boston & Albany					%	1.3	0.3			3.9	5.4				0.3	0.5		5.7	6.0	11.7		
											No.	8	2			25	33				2	3		36	38	74		

DATA FOR DIAGRAM 3.

The upper figures give Failures per 10000 Tons of New Rail Laid.

___ lb. ____ Section Bessemer Steel. Rolled by __________ Steel Co.

Comparison between different Sections of Rail. Railroad

Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

Record for period of ~~one year~~ 6 Months ending Oct. 31 ____ 1909. 64

~~Year Laid~~ Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
		~~C.~~ Wt.	~~P.~~ Kind of Steel.	~~Mn.~~	~~Si.~~	S.		Freight	Passenger			Broken		~~Flow of Metal~~		~~Crushed~~ Head		~~Split Head~~		Split Web		Broken Base		Total			Last Year	Present Year
												Tang.	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	Tang	Curve	Tang	Curve			
A.S.C.E.	568223	90	Bessemer.			8 Companies					%	2.1	1.1			6.4	5.9			0.5	0.3	0.4	0.3	9.4	7.6	17.0		
											No.	121	62			364	335			26	19	21	17	532	433	965		
Buffalo, Rochester & Pittsb. 10000 Tons – Central R.R. of N. Jersey										53085	%																	
											No.	Chgo. & Northwestern 174301 – Cleve. Cinti. Chgo. & St. Louis 88986.																
Delaware, Lackawanna & West'n. 41026 – Hocking Valley 5610.											%																	
											No.	Pitts. & Lake Erie 35366 – Phila. & Reading 159849.																
ARA^{A}	5100	90	Bessemer.			Balto. & Ohio.					%	2.0				7.8								9.8		9.8		
											No.	1				4								5		5		
ARA^{B}	28450	90	Bessemer.			2 Companies					%	0.3	0.7			3.2	11.2			0.4	0.4			3.9	12.3	16.2		
											No.	1	2			9	32			1	1			11	35	46		
Balto. & Ohio 22450 Tons – Balto. & Ohio S. Western 6000											%																	
											No.																	
~~Dudley~~ A.S.C.E.	21800	90	Bessemer			Buffalo, Rochester & Pittsburgh					%	0.9				4.6	5.0						0.5	5.5	5.5	11.0		
											No.	2				10	11						1	12	12	24		
Great North'n.	40529	90	Bessemer			Great Northern.					%		0.2			0.7	1.8							0.7	2.0	2.7		
											No.		1			3	7							3	8	11		
Common Stand'd.	99798	90	Bessemer			5 Companies. Harriman Lines					%	1.0	0.5			5.9	4.4			1.1	0.2	0.3		8.3	5.1	13.4		
											No.	10	5			59	44			11	2	3		83	51	134		
Galveston, Harrisburg & San Antonio 7252 Tons – Illinois Central 2473											%																	
											No.	Oregon Short Line 2598 – Texas & New Orleans 296 – Union Pacific 87179																
											%																	
											No.																	
All	763900	90	Bessemer			16 Companies					%	1.8	1.0			5.9	5.6			0.5	0.3	0.3	0.2	8.5	7.1	15.5		
											No.	135	70			449	429			38	22	24	18	646	539	1185		

DATA FOR DIAGRAM 3.

The upper figures give Failures per 10000 Tons of New Rail Laid.

Comparison between different Sections of Rail. Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

Record for period of ~~one year~~ 6 Months ending Oct. 31 1909 65

lb. Section Bessemer Steel. Rolled by Steel Co.

~~Year Laid~~ Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
												Broken		~~Flow of Metal~~		~~Crushed~~ Head		~~Split Head~~		Split Web		Broken Base		Total				
		~~C.~~ Wt.	~~P.~~ Kind of Steel	~~Mn.~~	~~Si.~~	S.		Freight	Passenger			Tang.	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	Tang.	Curve	Tang	Curve		Last Year	Present Year
P.R.R	124368	85	Bessemer			4 Companies.					%	1.2	0.3			3.4	1.7			0.6		0.3	0.1	5.5	2.1	7.6		
											No.	15	4			42	21			7		4	1	68	26	94		
Balto. Chesapeake & Atlantic 674 Tons – Cumberland Valley 5008											%																	
											No.	Penn'a R.R. Lines East 8623 + Penn'a. Lines West 110063																
A.S.C.E.	2138851	85	Bessemer			19 Companies.					%	1.4	0.6			4.9	3.9			0.4	0.2	0.7	0.3	7.4	5.0	12.4		
											No.	295	127			1038	836			95	45	145	67	1573	1075	2648		
Boston & Maine 56369 Tons – Chesapeake & Ohio 51471 – Chicago & Eastern											%																	
											No.	Illinois 25112 + Evansville & Terre Haute 4705 – Ft. Worth & Denver City 11535																
Grand Rapids & Indiana 11600 – Illinois Central 317125 – Norfolk & West'n.											%																	
											No.	213000 – Nor. Pacific 198756 + Penn'a. Lines West 443362 – Rock Island Lines 142006																
St. Louis & San Francisco 16170 – Southern Ry. 27757 + Vandalia 18821											%																	
											No.	Atchison, Topeka & Santa Fe 56190 – Atlantic Coast Line 69520 + Balto. & Ohio 367511																
Balto. & Ohio Sou'west'n. 93479 – Bangor & Aroostook 14362.											%																	
											No.																	
P.S.	21800	85	Bessemer			2 Companies.					%	0.9	0.5			6.8	35.8			1.4	3.7			9.1	40.0	49.1		
											No.	2	1			15	78			3	8			20	87	107		
Penn'a. R.R. Lines East 3933 Tons – Penn'a. Lines West 17867											%																	
											No.																	
A. A.R.A.	16932	85	Bessemer			Atchison, Topeka & Santa Fe					%					2.9	1.2			1.2	0.6	0.6		4.7	1.8	6.5		
											No.					5	2			2	1	1		8	3	11		
C.B.&Q.	363870	85	Bessemer			Chgo. Burlington & Quincy.					%	0.3	0.7			3.3	3.2			0.2	0.1	0.3	0.2	4.1	4.2	8.3		
											No.	12	25			119	116			8	5	11	6	150	152	302		
Great Northn.	122961	85	Bessemer			Great Northern.					%	0.2	0.2			5.0	6.1			0.1	0.1	1.5	0.1	6.8	6.5	13.3		
											No.	2	2			52	63			1	1	15	1	70	67	137		
											%																	
											No																	
All	2768782	85	Bessemer			24 Companies.					%	1.2	0.6			4.6	4.0			0.4	0.2	0.6	0.3	6.8	5.1	11.9		
											No	326	159			1271	1116			116	60	176	75	1889	1410	3299		

DATA FOR DIAGRAM 3.
The upper figures give Failures per 10000
Tons of New Rail Laid.

Comparison between different Sections of Rail Railroad
Summary of Steel Rail Failures for ~~One Year~~ compared with same period of previous year.

--- lb. ---- Section Bessemer Steel. Rolled by ---------- Steel Co.

Record for period of ~~one year~~ 6 Months ending -- Oct 31 --- 1909 66

~~Year Laid~~ Sec.	Tons of New Rail Laid	Specified Chemical Analysis				Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
										Broken		~~Flow of Metal~~		~~Crushed~~ Head		~~Split Head~~		Split Web		Broken Base		Total			Last Year	Present Year
		~~C~~ Wt.	~~P~~ ~~Mn~~ ~~Si~~ Kind of Steel	S.		Freight	Passenger			Tang	Curve	~~Tang~~	~~Curve~~	Tang	Curve	~~Tang~~	~~Curve~~	Tang.	Curve	Tang	Curve	Tang	Curve			
ASCE	1357537	80	Bessemer	24 Companies.					%	1.0	0.3			6.5	2.0			0.5	0.1	0.2	0.1	8.2	2.5	10.7		
									No.	135	34			883	286			65	14	24	8	1107	342	1449		
Central of N.England 3787 Tons - Chicago & Eastern Illinois 43643									%																	
									No.	Chgo.& Norwestern. 85975 - Cleve. Cin. Chgo.& St.Louis 146594 - Del. Lack.& Westn. 38799																
Evansville & T.Haute 5473 - Galveston, Harrisburg & San Antonio 48064									%																	
									No.	Grand Trunk 138398 - Houston & Texas Central 37728 - Lake Shore & Mich. Sou. 162163																
Lake Superior & Ishpeming 2500 - Lehigh & Hudson River 8474									%																	
									No.	Louisiana Western 9994 - Marquette & Sou. East'n. 1941 - Memissing R.R. 2083																
Mich. Central 42776 - Oregon Short Line 42501 - Pitts.& Lake Erie 16915									%																	
									No.	Rock Island Lines 309741 - St.Joseph & Grand Island 9159 - Sou. Pacific 47311																
Southern Ry. 42113 - Temiskaming & N.Ontario 6552.									%																	
									No.	Union Pacific 104853																
~~NY.NH &H.~~	17565	80	Bessemer	N.York. N.Haven & Hartford.				A.S.C.E Sec.	%		1.1				1.1			1.1	0.6	1.7		2.8	2.8	5.6		
									No.		2				2			2	1	3		5	5	10		
Dudley	206857	80	Bessemer	4 Companies					%	0.9	0.8			1.2	1.1			0.3	0.0			2.4	1.9	4.3		
									No.	19	16			24	23			6	1			49	40	89		
Hocking Valley 3140 Tons - New York Central & Hudson River 191905									%																	
									No.	Pitts.& Lake Erie R.R. 3500 - Toledo & Ohio Central 8312																
Great North'n	52532	80	Bessemer	Great Northern					%	2.5	0.2			6.8	1.5			0.8		12.0	0.9	22.1	2.6	24.7		
									No.	13	1			36	8			4		63	5	116	14	130		
~~Common. Stand.~~	27491	80	Bessemer	Oregon R.R.& Nav. Co.				(Harriman Lines Sec.) A.S.C.E. Sec	%		0.4			2.9	4.3			0.4			0.3	3.3	5.0	8.3		
									No.		1			8	12			1			1	9	14	23		
A.S.C.E ~~Canadl~~	17388	80	Bessemer	Temiskaming & N.Ontario					%	2.3	1.1			4.0	16.1					3.0	2.3	9.3	19.5	28.8		
									No.	4	2			7	28					5	4	16	34	50		
Special 540	2500	80	Bessemer	Hocking Valley					%	4.0												4.0		4.0		
									No.	1												1		1		
									%																	
									No.																	
All	1681870	80	Bessemer	30 Companies					%	1.0	0.3			5.7	2.2			0.5	0.1	0.5	0.1	7.7	2.7	10.4		
									No.	172	56			958	359			78	16	95	18	1303	449	1752		
									%																	
									No.																	
NY,NH &H	17957	78	Bessemer	N.York. N.Haven & Hartford					%		1.1				0.6				1.1				2.8	2.8		
									No.		2				1				2				5	5		

DATA FOR DIAGRAM 3.

The upper figures give Failures per 10,000 Tons of New Rail Laid.

--- lb. ---- Section *Bessemer* Steel. Rolled by ---------- Steel Co.

Comparison between different Sections of Rail Railroad

Summary of Steel Rail Failures for ~~One Year~~ *6 Months* compared with same period of previous year.

Record for period of ~~one year~~ ending *Oct. 31* 19*09* *67*

~~Year Laid~~ Sec.	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure															Failures per 10,000 tons of New Rail laid	
												Broken		~~Flow of Metal~~		~~Crushed~~ Head		~~Split Head~~		Split Web		Broken Base		Total		Grand Total		
		~~C.~~ Wt.	~~P.~~ Kind of Steel	~~Mn.~~	~~Si.~~	S.		Freight	Passenger			Tang	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
A.S.C.E.	407808	75	Bessemer			7 Companies					%	0.9	0.8			1.4	1.8			0.6	0.6	0.4	0.2	3.3	3.4	6.7		
											No.	35	33			56	74			26	24	15	7	132	138	270		
Boston & Maine 133550 Tons – Ft. Worth & Denver City 25768											%																	
											No.	Illinois Central 136772 – Norfolk & Westn. 6000 – St. Louis & San Francisco 46900																
Southern Ry. 29023 – Toledo, St. Louis & Western 29795.											%																	
											No.																	
Common Standd.	135971	75	Bessemer			9 Companies (Harriman Lines Section)					%	2.5	7.1			9.7	7.9			1.4	3.2	0.2	0.1	13.8	18.3	32.1		
											No.	34	96			132	108			19	43	3	1	188	248	436		
Galveston, Harrisburg & San Antonio 31168 Tons – Houston & Texas Central											%																	
											No.	15699 – Louisiana & Westn. 2634 – Morgan's Louisiana & Texas R.R. 6827																
Oregon R.R. & Nav. Co. 24919 – Oregon Short Line 2344 – St. Joseph &											%																	
											No.	Grand Island 1526 – Southn. Pacific 32511 – Union Pacific 18343.																
B&M	41263	75	Bessemer			2 Companies					%	0.3	1.0								0.5	0.2	0.2	0.5	1.7	2.2		
											No.	1	4								2	1	1	2	7	9		
Maine Central 37063 Tons – Somerset Ry. 4200											%																	
											No.																	
C&O	26957	75	Bessemer			Chesapeake & Ohio					%						1.1								1.1	1.1		
											No.						3								3	3		
											%																	
											No.																	
All	611999	75	Bessemer			19 Companies					%	1.1	2.2			3.1	3.0			0.8	1.1	0.3	0.1	5.3	6.4	11.7		
											No.	70	133			188	185			45	69	19	9	322	396	718		
											%																	
											No.																	
A.S.C.E.	26684	72	Bessemer			Northern Pacific					%					1.5	0.8			0.3				1.8	0.8	2.6		
											No					4	2			1				5	2	7		
Special 7201	202665	72	Bessemer			Chgo. & North Western					%	0.95	0.27			1.05	0.28			0.05	0.05	0.05		2.1	0.6	2.7		
											No.	19	6			21	6			1	1	1		42	13	55		
											%																	
											No																	
All	229349	72	Bessemer			2 Companies					%	0.83	0.23			1.09	0.37			0.09	0.05	0.05		2.0	0.7	2.7		
											No.	19	6			25	8			2	1	1		47	15	62		

DATA FOR DIAGRAM 4.
The upper figures give Failures per 10000
Tons of New Rail Laid.

Comparison between different Sections of Rail Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

--- lb. ---- Section Open Hearth Steel. Rolled by ---------- Steel Co.

Record for period of ~~one year~~ ending Oct 31 1909 68

~~Year Laid~~ Sec	Tons of New Rail Laid	Specified Chemical Analysis						Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure															Failures per 10,000 tons of New Rail laid	
		~~C.~~ Wt.	~~P.~~ Kind of Steel	~~Mn.~~	~~Si.~~	S.		Freight	Passenger			Broken		~~Flow of Metal~~		~~Crushed~~ Head		~~Split Head~~		Split Web		Broken Base		Total		Grand Total	Last Year	Present Year
												Tang.	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	~~Tang.~~	~~Curve~~	Tang.	Curve	Tang.	Curve	Tang	Curve			
ASCE	38653	100	Open Hearth			3 Companies					%	0.3				2.3				1.3		1.0		4.9		4.9		
											No.	1				9				5		4		19		19		
Grand Trunk 34382 Tons – Mich. Central 3811 – Lehigh & Hudson River 460											%																	
											No.																	
PS	11266	100	Open Hearth			2 Companies					%	3.6				6.2								9.8		9.8		
											No.	4				7								11		11		
Penna. R.R. Lines East 1352 Tons – Penna. Lines West 9914.											%																	
											No.																	
NY, NH & H	4300	100	Open Hearth			N. York, N. Haven & Hartford					%	2.3								7.0	4.7	2.3		11.6	4.7	16.3		
											No.	1								3	2	1		5	2	7		
Dudley	2274	100	"	"		N. York Central & Hudson River					%																	
											No.																	
All	56493	100	"	"		7 Companies					%	1.0				2.8				1.4	0.4	0.9		6.1	0.4	6.5		
											No.	6				16				8	2	5		35	2	37		
											%																	
											No.																	
ASCE	7661	90	Open Hearth			2 Companies					%	6.5	14.4			15.7	7.8			6.5	1.3	2.6	1.3	31.3	24.8	56.1		
											No.	5	11			12	6			5	1	2	1	24	19	43		
Buffalo, Rochester & Pittsb. 1500 Tons – Cent'l R.R. of N. Jersey 6161											%																	
											No.																	
ARA^A	66700	90	Open Hearth			2 Companies					%	0.2				4.6	1.8			0.6				5.4	1.8	7.2		
											No.	1				31	12			4				36	12	48		
Balto. & Ohio 2000 Tons – Chgo. Burlington & Quincy 64700											%																	
											No.																	
ARA^B	32215	90	Open Hearth			2 Companies					%	0.9	1.5			1.9	9.7			0.3	1.5			3.1	12.7	15.8		
											No	3	5			6	31			1	5			10	41	51		
Balto. & Ohio 8600 Tons – Northern Pacific 23615											%																	
											No																	
Great North'n	32666	90	Open Hearth			Great Northern.					%					2.8	0.9			0.9				3.7	1.2	4.9		
											No					9	3			3				12	4	16		
Common Stand.	8992	90	"	"	-	3 Companies (Harriman Lines Section)					%	3.4				1.1	11.1			2.2	1.1	1.1		7.8	12.2	20.0		
											No.	3				1	10			2	1	1		7	11	18		
Galveston, Harrisburg & San Antonio 3202 Tons – Illinois Central 2473											%																	
											No.	Southern Pacific 3317																
DL&W	26822	90	Open Hearth			Delaware, Lackawanna & Western					%	3.4	7.1			1.0	0.4			0.4	2.2	0.4		5.2	9.7	14.9		
											No.	9	19			3	1			1	6	1		14	26	40		
All	175056	90	"	"		10 Companies					%	1.2	2.0			3.5	3.6			1.0	0.7	0.2	0.1	5.9	6.4	12.3		
											No.	21	35			62	63			16	13	4	2	103	113	216		

DATA FOR DIAGRAM 4.

The upper Figures give Failures per 10,000 Tons of New Rail Laid

--- lb. ---- Section Open Hearth Steel. Rolled by ---------- Steel Co.

Comparison between different Sections of Rail Railroad

Summary of Steel Rail Failures for ~~One Year~~ 6 Months compared with same period of previous year.

Record for period of ~~one year~~ ending Oct. 31 1909 69

~~Year Laid~~ Sec	Tons of New Rail Laid	Specified Chemical Analysis				Maximum Axle Load of Locomotives.		Approximate Gross Tons over Rail.		Kind of Failure														Grand Total	Failures per 10,000 tons of New Rail laid	
										Broken		~~Flow of Metal~~		~~Crushed~~ Head		~~Split Head~~		Split Web		Broken Base		Total				
		Wt.	Kind of Steel	S.		Freight	Passenger			Tang.	Curve	~~Tang~~	~~Curve~~	Tang	Curve	~~Tang~~	~~Curve~~	Tang.	Curve	Tang	Curve	Tang	Curve		Last Year	Present Year
A.S.C.E.	81723	85	Open Hearth	7 Companies					%	0.8	1.0			2.0	2.0			0.4	0.1	0.1		3.3	3.1	6.4		
									No.	7	8			16	16			3	1	1		27	25	52		
									%																	
Boston & Maine 8220 Tons – Illinois Central 11833 – Norfolk & West'n 16000									No	Penna. Lines West 480 – Rock Island Lines 1749 – St. Louis & San Francisco 10000																
									%																	
Southern Ry. 33441									No.																	
P.S	8415	85	Open Hearth	2 Companies					%	1.2				2.3	2.3				1.2			3.5	3.5	7.0		
									No.	1				2	2				1			3	3	6		
									%																	
Penna. Lines East 2494 Tons – Penna. Lines West 5921									No.																	
C.B.&Q.	10000	85	Open Hearth	Chgo. Burlington & Quincy					%					2.0	2.0			2.0		2.0		6.0	2.0	8.0		
									No.					2	2			2		2		6	2	8		
Great North'n	10043	85	" "	Great Northern					%	2.0	1.0			9.0	14.0			1.0			3.0	12.0	18.0	30.0		
									No.	2	1			9	14			1			3	12	18	30		
All	110181	85	" "	10 Companies					%	0.9	0.8			2.7	3.1			0.5	0.2	0.3	0.3	4.4	4.4	8.8		
									No.	10	9			29	34			6	2	3	3	48	48	96		
									%																	
									No.																	
A.S.C.E.	231209	80	Open Hearth	8 Companies					%	1.3	0.7			6.0	1.9			1.3	1.3	0.7	0.1	9.3	4.0	13.3		
									No.	30	16			138	44			30	30	17	2	215	92	307		
									%																	
Central R.R. of N. England 1235 Tons – Cleve. Cinti. Chgo. & St. Louis 1050									No.	Galveston, Harrisburg & San Antonio 7007 – Grand Trunk 26974																
									%																	
Louisville & Nashville 119726 – Nashville, Chattanooga & St. Louis 16261									No.	Rock Island Lines 123 – Southern Ry. 58833.																
N.Y., N.H. & H.	975	80	Open Hearth	N. York, N. Haven & Hartford					%	10.3												10.3	—	10.3		
									No	1												1		1		
All	232184	80	" "	9 Companies					%	1.3	0.7			6.0	1.9			1.3	1.3	0.7	0.1	9.3	4.0	13.3		
									No	31	16			138	44			30	30	17	2	216	92	308		
									%																	
									No																	
A.S.C.E.	37491	75	Open Hearth	Southern Ry.					%	2.7	0.5							0.5		0.3		3.5	0.5	4.0		
									No.	10	2							2		1		13	2	15		

DATA FOR DIAGRAM 5. Comparison of Failures of Various Sections at different Lengths of Life: Bessemer & Open Hearth Steel.

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Summary of Steel Rail Failures for 6 Months Compared with same Period of Previous Year

____lb ________Sec ____________Steel. Rolled by ____________Steel Co Record for Period of 6 Mos. ending Oct. 31 1909

100 LB. RAIL				
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURES	NO. OF FAILURES PER 10,000 TONS LAID
P.R.R	0-1	3800	10	26.3
"	1-2	8061	33	40.9
"	2-3	2936	1	3.4
"	3-4	2733	1	3.7
"	4-5	3248	2	6.2
"	5-6	1973	3	15.2
"	6-7	1269	2	15.8
Total		24020	52	
A.S.C.E.	0-1	43260	12	2.8
"	1-2	38809	17	4.4
"	2-3	142036	169	11.9
"	3-4	98271	120	12.2
"	4-5	84683	186	22.0
"	5-6	20763	67	32.3
"	6-7	7328	4	5.0
"	7-8	33865	13	3.8
"	8-9	12470	4	3.2
Total		481485	592	
P.S.	0-1	38073	37	9.7
"	1-2	4405	8	18.1
"	2-3	1000		
Total		43478	45	
NYNH&H.	0-1	4300	7	16.3
"	1-2	4299	1	2.3
"	2-3	3583	2	5.6
"	7-8	6422	2	3.1
"	8-9	1427	1	7.0
Total		20031	13	
A.R.A. ^{A}	0-1	3178	2	6.3

100 LB. RAIL				
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURES	NO. OF FAILURES PER 10000 TONS LAID
A.R.A. ^{B}	0-1	13900	7	5.4
"	1-2	566	2	35.3
Total		14466	9	
Dudley	0-1	2100		
"	1-2	19114	2	1.0
"	2-3	25377	28	11.0
"	3-4	22078	10	4.5
"	4-5	48402	26	5.4
"	5-6	25260	105	41.2
"	6-7	7933	6	7.6
"	7-8	629		
"	8-9	1218		
Total		152111	177	

Boston & Albany	95 LB. RAIL			
	10^{+}	63378	74	11.3

90 LB. RAIL				
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURES	NO. OF FAILURES PER 10000 TONS LAID
A.S.C.E.	0-1	25633	60	23.4
"	1-2	60592	94	15.5
"	2-3	92528	168	18.1
"	3-4	107760	375	34.8
"	4-5	87568	126	14.4
"	5-6	41167	48	16.7
"	6-7	54380	64	11.8
"	7-8	36005	14	3.9
"	8-9	22461	18	8.0
"	9-10	25265	28	11.8
"	10^{+}	22525	13	5.8
Total		575884	1008	
A.R.A. ^{A}	0-1	70300	50	7.1
"	1-2	1500	3	20.0
Total		71800	53	
A.R.A. ^{B}	0-1	58065	56	9.6
"	1-2	2600	41	157.7
Total		60665	97	
~~Dudley~~	~~2-3~~	~~3800~~	~~20~~	~~52.7~~
~~"~~	~~3-4~~	~~3400~~	~~1~~	~~2.9~~
~~"~~	~~6-7~~	~~7600~~	~~1~~	~~1.3~~
~~"~~	~~7-8~~	~~7000~~	~~2~~	~~2.9~~
~~Total~~		~~21800~~	~~24~~	
Great Northn.	0-1	22813	10	4.4
"	1-2	50382	17	3.4
Total		73195	27	

90 LB. RAIL				
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURES	NO. OF FAILURES PER 10000 TONS LAID
C.S.-Common Standard Sec.			Harriman Lines.	
C.S.	0-1	5675	8	14.1
"	1-2	8039	20	24.9
"	2-3	33341	47	14.1
"	3-4	61735	77	12.5
Total		108790	162	
D.L.&W.	0-1	17786	39	21.9
"	1-2	9036	1	1.1
Total		26822	40	

DATA FOR DIAGRAM 5. Comparison of Failures of Various Sections at different Lengths of Life. Bessemer and Open Hearth Steel.

Summary of Steel Rail Failures for 6 Months Compared with same Period of Previous Year 71

——lb —— ——Sec ——————Steel. Rolled by ——————————Steel Co Record for Period of *6 Mos.* ending *Oct. 31* 19*09*

85 LB. RAIL				
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURES	NO OF FAILURES PER 10000 TONS LAID
P.R.R	0-1	2028	5	24.6
"	1-2	6800	14	20.6
"	2-3	335		
"	3-4	134		
"	7-8	1126	3	26.6
"	8-9	887	1	11.3
"	9-10	1128	1	8.9
"	10+	111830	70	6.3
Total		124368	94	
A.S.C.E	0-1	72297	62	8.6
"	1-2	146284	407	27.8
"	2-3	349615	459	13.1
"	3-4	356838	282	7.9
"	4-5	247855	174	7.0
"	5-6	204971	257	12.5
"	6-7	255947	282	11.0
"	7-8	157712	117	7.4
"	8-9	149111	88	5.9
"	9-10	153511	238	15.5
"	10+	126433	334	26.4
Total		2220574	2700	
P.S	0-1	28354	109	38.4
"	1-2	1861	4	21.5
Total		30215	113	
A.R.A.A	0-1	8658	3	3.5
"	1-2	582	1	17.2
"	2-3	15	2	0.0
"	3-4	7677	5	6.5
Total		16932	11	

85 LB. RAIL				
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURS	NO OF FAILURES PER 10000 TONS LAID
C.B.&Q.	0-1	76125	5	0.7
"	1-2	79510	51	6.4
"	2-3	61835	127	20.5
"	3-4	77650	102	13.1
"	4-5	36750	20	5.4
"	5-6	42000	5	1.2
Total		373870	310	
Great Northn.	1-2	8500		
"	2-3	56164	118	21.1
"	3-4	48340	49	10.1
Total		113004	167	

80 LB. RAIL				
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURES	NO. OF FAILURES PER 10000 TONS LAID
A.S.C.E.	0-1	31253	11	3.5
"	1-2	40388	28	6.9
"	2-3	84056	75	8.9
"	3-4	86766	189	21.8
"	4-5	160354	173	11.2
"	5-6	149958	166	11.1
"	6-7	290134	230	7.9
"	7-8	172041	149	8.7
"	8-9	190303	180	9.5
"	9-10	127553	302	23.7
"	10+	255940	247	9.7
Total		1588746	1756	
~~NY.NH&H~~	~~0-1~~	~~975~~	~~1~~	~~10.3~~
~~"~~	~~1-2~~	~~8782~~	~~1~~	~~1.1~~
~~"~~	~~2-3~~	~~8783~~	~~9~~	~~10.2~~
~~Total~~		~~18540~~	~~11~~	
Dudley	0-1	1600	6	37.5
"	1-2	27412	9	3.3
"	2-3	36406	10	2.8
"	3-4	35050	17	4.9
"	4-5	8535	9	10.5
"	5-6	7831	6	7.7
"	6-7	20558	5	2.4
"	7-8	13881	7	5.0
"	8-9	20502	10	4.9
"	9-10	14326	2	1.4
"	10+	20756	8	3.9
Total		206857	89	

80 LB. RAIL				
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURES	NO. OF FAILURES PER 10000 TONS LAID
Great Northn.	1-2	550		
"	2-3	1144	1	8.7
"	4-5	45310	119	26.2
"	5-6	5528	10	18.1
Total		52532	130	
Common Standard Sec. Harriman Lines				
C.S	4-5	21633	10	4.6
"	5-6	5858	13	22.2
Total		27491	23	
Cammell	5-6	10206	18	17.6
"	6-7	7182	32	44.5
Total		17388	50	
Special	Cambria Steel Co. No. 540			
"	5-6	2500	1	

78 LB. RAIL				
NY.NH&H	3-4	12072	2	1.7
"	5-6	4000	2	5.0
"	6-7	1885	1	5.3
Total		17957	5	

DATA FOR DIAGRAM 5. Comparison of Failures of Various Sections at Different Lengths of Life. Bessemer and Open Hearth Steel.

Summary of Steel Rail Failures for 6 Months Compared with same Period of Previous Year

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lb. ______ Sec. ______ Steel. Rolled by ______ Steel Co Record for Period of 6 Mos. ending Oct. 31 1909

		75 LB. RAIL		
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURES	NO. OF FAILURES PER 10000 TONS LAID
A.S.C.E	2-3	34307	26	7.5
"	3-4	37953	18	4.7
"	4-5	53813	28	5.2
"	5-6	20025	13	6.5
"	6-7	21865	10	4.6
"	7-8	41644	20	4.8
"	8-9	13188	4	3.0
"	9-10	13619	3	2.2
"	10^+	208885	163	7.8
Total		445299	285	
Common Standard Sec. Harriman Lines				
C.S	0-1	195	. 1	0.0
"	1-2	18076	5	2.2
"	2-3	37532	183	48.8
"	3-4	26303	161	61.2
"	4-5	3119	56	179.5
"	5-6	4		0.0
"	8-9	10595	6	5.7
"	9-10	10067	5	5.0
"	10^+	30080	19	6.3
Total		135971	436	
B&M	2-3	4200	0	0.0
"	5-6	4725	3	6.3
"	6-7	3150	4	12.7
"	7-8	6300	2	3.2
"	8-9	3528	0	0.0
"	9-10	2952	0	0.0
"	10^+	16408	0	0.0
Total		41263	9	
C&O	6-7	4501	1	2.2
"	9-10	14025	1	0.7
"	10^+	8431	1	1.2
Total		26957	3	

		72 LB. RAIL		
SEC.	LIFE IN YEARS	TONS LAID	NO. OF FAILURES	NO. OF FAILURES PER 10000 TONS LAID
A.S.C.E.	8-9	26684	7	2.6
Special 7201	0-1	5382	1	1.9
"	1-2	27262	2	0.7
"	2-3	16257	15	9.2
"	3-4	16697	8	4.8
"	4-5	14667	2	1.4
"	5-6	8640	1	1.2
"	6-7	14866	0	0.0
"	7-8	4928	5	1.0
"	8-9	4162	1	2.4
"	9-10	14639	0	0.0
"	10^+	75165	20	2.7
Total		202665	55	

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ATCHISON, TOPEKA AND SANTA FE RAILWAY - COAST LINES RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six (6) months ending October 31, 1909.

TYPE OF RAIL SECTION

Sheet No.
of Sheets

Kind of Failure	Co. Mill																Co. Mill															
	100 lb.								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken															1	1																
Flow of Metal															3	3																
Crushed Head																																
Split Head															14	14																
Split Web																																
Broken Base															1	1																
Totals															19	19																
	Co. Colorado Fuel & Iron Company Mill																Co. Mill															
Broken										1					5	6																
Flow of Metal																																
Crushed Head																																
Split Head									1			1			12	14																
Split Web											1					1																
Broken Base																																
Totals									1	1	1	1			17	21																
	Co. Lackawanna Steel Company Mill																Co. Mill															
Broken															1	1																
Flow of Metal																																
Crushed Head															5	5																
Split Head															3	3																
Split Web															2	2																
Broken Base															1	1																
Totals															12	12																

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ATCHISON, TOPEKA AND SANTA FE RAILWAY RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six (6) months **ending** October 31, 1909.

Sheet No

A R A TYPE OF RAIL SECTION

of Sheets

Kind of Failure	Co. Mill																Co. Mill															
	100 lb.								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																																
Flow of Metal													1			1																
Crushed Head																																
Split Head																									1							1
Split Web													1			1																
Broken Base																																
Totals													2			2									1							1
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head									1							1																
Split Web																																
Broken Base																																
Totals									1							1																

THE BALTIMORE AND OHIO RAILROAD COMPANY

MAINTENANCE OF WAY DEPARTMENT

A. L. L. Division

Position in Ingot of Steel Rails which failed for Period of Six Months ending October 31st 1909

A. R. A. "A" Type of Rail Section Sheet No. ___ of ___ Sheets

Kind of Failure		Illinois Steel Co. South Chicago Mill															
		90 lb.								100 lb.							
		A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	%	100															
	No	1	0	0	0	0	0	0	1								
Flow of Metal	%																
	No																
Crushed Head	%	100															
	No	3	0	0	0	0	0	0	3								
Split Head	%	100															
	No	1	0	0	0	0	0	0	1								
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%	100															
	No	5	0	0	0	0	0	0	5								
		Illinois Steel Co. Gary Plant Mill															
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushed Head	%																
	No																
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%																
	No																
		Co Mill															
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushe Head	%																
	No																
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%																
	No																

Kind of Failure		Co Mill															
		lb.								lb.							
		A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushed Head	%																
	No																
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%																
	No																
		Co Mill															
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushed Head	%																
	No																
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%																
	No																
		Co Mill															
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushe Head	%																
	No																
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%																
	No																

Note - The letters A. B. C. etc denote the position of the Rail in the ingot. "A" being the top Rail. "B" the second, etc.

200 1-27-09

Form 988 Spl

THE BALTIMORE AND OHIO RAILROAD COMPANY

~~THE BALTIMORE AND OHIO SOUTHWESTERN RAILROAD COMPANY~~

MAINTENANCE OF WAY DEPARTMENT

L. L. Division

Position in Ingot of Steel Rails which failed for Period of Six Months ending October 31st 1909

A R A "B" Type of Rail Section Sheet No. of Sheets

Kind of Failure		Carnegie Steel Co								Edgar Thompson Mill							
		90 lb								100 lb.							
		A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushed Head	%	50.0						50.0									
	No	1	0	0	0	0	0	1	2								
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%	50.0						50.0									
	No	1	0	0	0	0	0	1	2								

Kind of Failure		Bethlehem Steel Co								South Bethlehem Mill							
		90lb								100lb.							
		A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	%	14.3			14.2	42.8	14.3	14.3									
	No	1	0	0	1	3	1	1	7								
Flow of Metal	%	100															
	No	1	0	0	0	0	0	0	1								
Crushed Head	%	18.8		12.5	12.5	6.26	6.26	43.8									
	No	3	0	2	2	1	1	7	16								
Split Head	%	50.0		11.2	27.8			11.2									
	No	9	0	2	5	0	0	2	18								
Split Web	%	16.7			50.0	16.7	16.7										
	No	1	0	0	3	1	1	0	6								
Broken Base	%																
	No																
Totals	%	31.3		8.34	22.9	10.4	6.26	20.9									
	No	15	0	4	11	5	3	10	48								

		Maryland Steel Co								Sparrows Point Mill							
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushed Head	%									25.0	50.0			25.0			
	No									1	2	0	0	1	0	0	4
Split Head	%	66.7	33.3							100							
	No	2	1	0	0	0	0	0	3	1	0	0	0	0	0	0	1
Split Web	%															100	
	No									0	0	0	0	0	0	1	1
Broken Base	%										100						
	No									0	1	0	0	0	0	0	1
Totals	%	66.7	33.3							28.6	42.8			14.3		14.3	
	No	2	1	0	0	0	0	0	3	2	3	0	0	1	0	1	7

		Illinois Steel Co								South Chicago Mill							
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushed Head	%																
	No																
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%																
	No																

		Cambria Steel Co								Johnstown Mill							
Broken	%	50.0						50.0									
	No	1	0	0	0	0	0	1	2								
Flow of Metal	%		100														
	No	0	1	0	0	0	0	0	1								
Crushe Head	%	33.3	33.3	22.2			11.2										
	No	3	3	2	[illegible]	0	1	0	9								
Split Head	%		50.0			25.0	25.0										
	No	0	2	0	0	1	1	0	4								
Split Web	%				100												
	No	0	0	0	1	0	0	0	1								
Broken Base	%																
	No																
Totals	%	23.5	35.3	11.8	5.89	5.89	11.8	5.89									
	No	4	6	2	1	1	2	1	17								

		Illinois Steel Co								Cary Plant Mill							
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushe Head	%																
	No																
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%																
	No																

Note - The letters A. B. C. etc denote the position of the Rail in the ingot, "A" being the top Rail, "B" the second, etc

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900 1-27-09

Form 983 Spl.

THE BALTIMORE AND OHIO RAILROAD COMPANY

~~THE BALTIMORE AND OHIO SOUTHWESTERN RAILROAD COMPANY~~

MAINTENANCE OF WAY DEPARTMENT

A. L. L. Division

Position in Ingot of Steel Rails which failed for Period of Six Months ending October 31st 1909.

A S C E Type of Rail Section

Sheet No. ____ of ____ Sheets

		Carnegie Steel Co.								Edgar Thompson Mill							
		85 lb.								100 lb.							
Kind of Failure		A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	%							100									
	No	0	0	00	0	0	0	13	13								
Flow of Metal	%	6.67	20.0	26.6	0	0	0	46.7									
	No	1	3	4	0	0	0	7	15								
Crushed Head	%	28.8	7.52	18.6	4.87	.89	.44	38.9									
	No	65	17	42	11	2	1	88	226								
Split Head	%	2.04	13.3	17.4	5.11	0	0	62.3									
	No	2	13	17	5	0	0	61	98								
Split Web	%							100									
	No	0	0	0	0	0	0	30	30								
Broken Base	%							100									
	No	0	0	0	0	0	0	4	4								
Totals	%	17.6	8.50	16.3	4.15	.52	.26	52.7	100								
	No	68	33	63	16	2	1	203	386								

		Illinois Steel Co								South Chicago Mill							
		85 lb.								100 lb.							
Kind of Failure		A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	%							100									
	No							4	4								
Flow of Metal	%																
	No							0	0								
Crushed Head	%							100									
	No							1	1								
Split Head	%							100									
	No							6	6								
Split Web	%																
	No							0	0								
Broken Base	%																
	No							0	0								
Totals	%																
	No							11	11								

		Maryland Steel Co								Sparrows Point Mill							
Broken	%	60.0	10.0			10.0		20.0		16.7		16.7				66.5	
	No	6	1	0	0	1	0	2	10	1	0	1	0	0	0	4	6
Flow of Metal	%	100															
	No	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Crushed Head	%	58.9	5.9		5.9	2.9		26.4		30.0	10.0	5.0		5.0		50.0	
	No	20	2	0	2	1	0	9	34	6	2	1	0	1	0	10	20
Split Head	%	38.9	5.56	0	11.1	5.56		38.9				7.71			7.71	84.7	
	No	7	1	0	2	1	0	7	18	0	0	1	0	0	1	11	13
Split Web	%	33.3	16.7					50.0								100	
	No	2	1	0	0	0	0	3	6	0	0	0	0	0	0	1	1
Broken Base	%				50.0			50.0									
	No	0	0	0	1	0	0	1	2	0	0	1	0	0	0	0	1
Totals	%	50.6	7.45		7.45	4.23		30.9		17.1	4.88	9.76		2.44	2.44	63.5	
	No	36	5	0	5	3	0	22	71	7	2	4	0	1	1	26	41

		Co								Mill							
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushed Head	%																
	No																
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%																
	No																

		Cambria Steel Co								Johnstown Mill							
Broken	%							100								100	
	No							10	10							2	2
Flow of Metal	%							100								100	
	No							20	20							1	1
Crushd Head	%							100								100	
	No							51	51							19	19
Split Head	%					6.67		93.5		11.1						88.9	
	No					1		14	15	1						8	9
Split Web	%							100								100	
	No							6	6							3	3
Broken Base	%															100	
	No							0	0							3	3
Totals	%																
	No								102								37

		Co								Mill.							
Broken	%																
	No																
Flow of Metal	%																
	No																
Crushd Head	%																
	No																
Split Head	%																
	No																
Split Web	%																
	No																
Broken Base	%																
	No																
Totals	%																
	No																

Note.—The letters A, B, C, etc. denote the position of the Rail in the ingot, "A" being the top Rail, "B" the second, etc.

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B. & O. S.-W. RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 Months ending October 31, 1909.

ARA-B TYPE OF RAIL SECTION

Sheet No.______

of______Sheets

Kind of Failure	CARNEGIE Co. E. T. Mill																Co. Mill															
	90 ~~100~~ lb. Rolled Aug 1908								85 lb.								100 lb.								85 lb.							
	A	B	C	1	3	4	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																																
Flow of Metal																																
Crushed Head				67.0 2	33.0 1			3																								
Split Head					50.0 1	50.0 1		2																								
Split Web																																
Broken Base																																
Totals				2	2	1		5																								
	CARNEGIE (Rolled Mar '09) Co. E. T. Mill																Co. Mill															
Broken		100.0 1						1																								
Flow of Metal			100.0 1					1																								
Crushed Head	33.0 5		67.0 10					15																								
Split Head							100.0 1	1																								
Split Web	100.0 1							1																								
Broken Base																																
Totals	6	1	11				1	19																								
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																

Boston and Albany RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 months **ending** October 31 **19**09

Sheet No. 79

of ____ Sheets

Dudley Sec. N.Y.C. Type TYPE OF RAIL SECTION

Kind of Failure	Lackawanna Steel Co.								Buffalo, N.Y. Mill									Lackawanna Steel Co.								Buffalo, N.Y. Mill							
	100 lb.								100 lb. ~~85 lb.~~ Ferro-Titanium									100 lb.								100 lb. ~~85 lb.~~ Ferro-Titanium							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total		A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken		2						2									August																
Flow of Metal																																	
Crushed Head																				1				2	3								
Split Head	1			1				2										3			2			2	7								
Split Web																		2							2								
Broken Base				1				1										1							1								
Totals	1	2		2				5								0		6		1	2			4	13								0
	Co.								Mill									Co.								Mill							
Broken																	September																
Flow of Metal																		1	1					10	12								
Crushed Head	1							1										3						1	4								
Split Head							1	1										1							1								
Split Web																				1					1								
Broken Base							1	1																									
Totals	1						2	3								0		5	1	1				11	18								0
	Co.								Mill									Co.								Mill							
Broken																	October	1	2						3			1					1
Flow of Metal																		1							1								
Crushed Head							1	1											1					1	2								
Split Head	1						3	4										1							1								
Split Web			1					1																									
Broken Base																																	
Totals	1		1				4	6								0		3	3					1	7			1					1

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CENTRAL RAILROAD COMPANY OF NEW JERSEY. RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 months **ending** Oct. 31, 1909.

Sheet No. ______

______ TYPE OF RAIL SECTION

of ______ Sheets

Kind of Failure	Maryland Steel Co. Mill															
	90 ~~100~~ lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken		3	1			1	10	15								
Flow of Metal	1	1					1	3								
Crushed Head	3	1	1	1			7	13								
Split Head	1	2	1				10	14								
Split Web	3						7	10								
Broken Base								0								
Totals	8	7	3	1		1	35	55								
	Carnegie Steel Co. Mill															
Broken					1		1	2								
Flow of Metal							0	0								
Crushed Head							1	1								
Split Head							2	2								
Split Web							0	0								
Broken Base							0	0								
Totals					1		4	5								
	Bethlehem Steel Co. Open Hearth Straight Carbon ~~Mill~~															
Broken	4	3	3	1	2		3	16								
Flow of Metal							1	1								
Crushed Head			3		1		3	7								
Split Head	2	2	1	1	1		1	8								
Split Web	1		4				1	6								
Broken Base		2					1	3								
Totals	7	7	11	2	4		10	41								

Kind of Failure	Lackawanna Steel Co. Mill															
	90 ~~100~~ lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	2	2	1	2			5	12								
Flow of Metal								0								
Crushed Head	4					2	13	19								
Split Head	5	1					4	10								
Split Web							1	1								
Broken Base							2	2								
Totals	11	3	1	2		2	25	44								
	Cambria Steel Co. Mill															
Broken				1			2	3								
Flow of Metal								0								
Crushed Head								0								
Split Head	1						11	12								
Split Web				1			1	2								
Broken Base																
Totals	1			2			14	17								
	Bethlehem Steel Co. Chrome Nickel ~~Mill~~															
Broken	24	36	38	29	20	0	15	162								
Flow of Metal																
Crushed Head	1			1			1	3								
Split Head	13	21	70	28	38	0	12	182								
Split Web				1	1	0	1	3								
Broken Base																
Totals	38	57	108	59	59	0	29	350								

The Chesapeake and Ohio Railway Company

Position in Ingot of Steel Rails which Failed, for Period of two months ending October 31 1909

Sheet No.______
of______Sheets

______TYPE OF RAIL SECTION

Carnegie Steel Co. Johnstown Mill																
Kind of Failure	100 lb. A.S.C.E.								85 lb A.S.C.E.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken															1	1
Flow of Metal																
Crushed Head																
Split Head															1	1
Split Web																
Broken Base																
Totals															2	2
Carnegie Steel Co. Edgar Thompson Mill																
Broken																
Flow of Metal							11	2							111	3
Crushed Head																
Split Head							11	2							111111	6
Split Web															1	1
Broken Base							1	1								
Totals								5								10
Maryland Steel Co. Sparrow's Point Mill																
Broken							1	1								
Flow of Metal															1	1
Crushed Head																
Split Head	1							1								
Split Web.																
Broken Base																
Totals								2								1

Co. Mill																
Kind of Failure	100 lb.								Old Sec 75 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																
Carnegie Steel Co. Edgar Thompson Old Sec. 75-lb. Mill																
Broken																
Flow of Metal															11	2
Crushed Head																
Split Head															1	1
Split Web																
Broken Base																
Totals																3
Maryland Steel Co. Sparrow's Point Old Sec. 75-lb Mill																
Broken																
Flow of Metal																
Crushed Head																
Split Head															1	1
Split Web.																
Broken Base																
Totals																

CHICAGO BURLINGTON and QUINCY RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 Months ending October 31st 1909

Sheet No 82 of Sheets

Type A.. 85# C.B&Q, 90# A.R.A., 100# A.S.C.E. } TYPE OF RAIL SECTION

Kind of Failure	Illinois Steel Co.								South Works Mill							
	100 lb. A.S.C.E.								85 lb. C.B&Q							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken									2	1					18	21
Flow of Metal															1	1
Crushed Head	1						1	2	14				1		75	90
Split Head	1							1	20	2	2	1		1	44	70
Split Web										1					10	11
Broken Base							1	1	1	1					12	14
Totals	2						2	4	37	5	2	1	1	1	160	207
	90# Col. Fuel and Iron. A.R.A. Co.								Pueblo C.B&Q Mill							
Broken															2	2
Flow of Metal															2	2
Crushed Head									1						11	12
Split Head									1						11	12
Split Web				1				1							3	3
Broken Base															3	3
Totals				1				1	2						32	34
	90# Illinois Steel A.R.A. Co.								South Works Mill							
Broken		1	1					2								
Flow of Metal			1				4	5								
Crushed Head	2		1				2	5								
Split Head	4	1	2	3		3	17	30								
Split Web		1	1			F G 1	2	5								
Broken Base																
Totals	6	3	6	3		3 1	25	47								

Kind of Failure	Carnegie Steel Co.								Edgar Thomson Mill							
	100 lb.								85 lb. C.B&Q							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken															8	8
Flow of Metal															1	1
Crushed Head															22	22
Split Head															27	27
Split Web															2	2
Broken Base															1	1
Totals															61	61
	Bethlehem Steel Co.								Bethlehem C.B&Q Mill							
Broken																
Flow of Metal																
Crushed Head									1							1
Split Head															3	3
Split Web												1			1	2
Broken Base															2	2
Totals									1			1			6	8
	Co.								Mill							
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

83

Cumberland Valley RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of *6 mo.* **ending** *Oct 31,* **1902**

Sheet No. *1*

of *1* Sheets

P.R.R. Std. TYPE OF RAIL SECTION

Kind of Failure	*Maryland Steel* Co. Mill																Co. Mill															
	100 lb.								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken			2					2							2	2																
Flow of Metal																																
Crushed Head															2	2																
Split Head	3					1	3	7							1	1																
Split Web															1	1																
Broken Base									1							1																
Totals	3		2			1	3	9	1						6	7																
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																

84

DELAWARE, LACKAWANNA AND WESTERN RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six (6) months ending October 31, 1909.

Sheet No.

of Sheets

TYPE OF RAIL SECTION

Kind of Failure	Bethlehem Steel Co. Mill															
	91 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	2	5	4	3	8		5	27								
Flow of Metal																
Crushed Head																
Split Head	1		1		2			4								
Split Web	1	2	1	1	1			6								
Broken Base			1					1								
Totals	4	7	7	4	11		5	38								
	Lackawanna Steel Co. Mill															
Broken		1						1								
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base							1	1								
Totals		1					1	2								
	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

Kind of Failure	Co. Mill															
	100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																
	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																
	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

85

GREAT NORTHERN RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six (6) months **ending** October 31st, 1909.

Sheet No.______

G.N. TYPE OF RAIL SECTION

of______Sheets

Kind of Failure	Bethlehem Steel Co.								South Bethlehem Mill							
	90 lb.															
	A	B	C	D	E	F	Unknown	Total	A	B	C.	D	E	F	Unknown	Total
Broken																
Flow of Metal					1			1								
Crushed Head		2	1				4	7								
Split Head	1				1	2		4								
Split Web	1					1		2								
Broken Base			1					1								
Totals	2	2	2		2	3	4	15								
	Algoma Steel Co.								Sault Ste. Marie Mill							
Broken							1	1								
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals							1	1								
	Illinois Steel Co.								Gary Mill							
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web						1		1								
Broken Base																
Totals						1		1								

Kind of Failure	Illinois Steel Co.								South Chicago Mill							
	100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																
Flow of Metal																
Crushed Head																
Split Head	1	1					1	3								
Split Web																
Broken Base																
Totals	1	1					1	3								
	Cambria Steel Co.								Conneaut Mill							
Broken				1				1								
Flow of Metal																
Crushed Head	1							1								
Split Head		1		1			1	3								
Split Web																
Broken Base																
Totals	1	1		2			1	5								
	Maryland Steel Co.								Sparrow's Point Mill							
Broken																
Flow of Metal																
Crushed Head							1	1								
Split Head	2							2								
Split Web																
Broken Base																
Totals	2						1	3								

86

ILLINOIS CENTRAL RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 Months ending October 31, 1909.

Sheet No ______

of ______ Sheets

______ TYPE OF RAIL SECTION

Kind of Failure	ILLINOIS STEEL Co. SOUTH CHICAGO Mill																Co. Mill															
	90 ~~100~~ lb								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	1							1		1			1		37	39																
Flow of Metal	1							1							6	6																
Crushed Head	1							1						2	6	8																
Split Head	5							5							21	21																
Split Web	1							1							7	7																
Broken Base															1	1																
Totals %	100 9							9		1.2 1			1.2 1	2.5 2	95.1 78	82																
	TENNESSEE COAL AND IRON Co. BIRMINGHAM Mill																Co. Mill															
Broken																																
Flow of Metal															8	8																
Crushed Head			1					1	3						5	9																
Split Head	1							1		1					5	6																
Split Web	1							1			1					1																
Broken Base		1		1				2							1	1																
Totals %	40 2	20 1	20 1	20 1				5	12 3	4 1	4 1				80 20	25																
	CARNEGIE STEEL Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head															9	9																
Split Web																																
Broken Base																																
Totals %															100 9	9																

The Lake Shore & Michigan Southern Railway RAILROAD

Sheet No. 87

of ______ Sheets

Position in Ingot of Steel Rails which Failed, for Period of 6 Months ending October 31, 1909. 19__

ASCE TYPE OF RAIL SECTION

Kind of Failure	Lackawanna Steel Co.								Lackawanna Mill							
	100 lb.								80 ~~85~~ lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken							9.0% 10	10								None
Flow of Metal							0%	0								"
Crushed Head							32.4% 36	36								"
Split Head							45.0% 50	50								"
Split Web							2.7% 3	3								"
Broken Base							10.8% 12	12								"
Totals							111	111								None
	Illinois Steel Co.								South Chicago Mill							
Broken	2.3% 3						11.5% 15	18							14.8% 4	4
Flow of Metal							0%	0							0	0
Crushed Head							27.7% 36	36							7.4% 2	2
Split Head			0.7% 1				36.9% 48	49							44.4% 12	12
Split Web							7.7% 10	10							7.4% 2	2
Broken Base							13.1% 17	17							25.9% 7	7
Totals	3		1				126	130							27	27
	Carnegie Steel Co.								Ohio Works Mill							
Broken							0	0								None
Flow of Metal							0%	0								"
Crushed Head							42.8% 3	3								"
Split Head							57.1% 4	4								"
Split Web							0	0								"
Broken Base							0	0								"
Totals							7	7								None

Kind of Failure	Co.								Mill							
	100 lb.								80 XXX lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																
	Co.								Mill							
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																
	Carnegie Steel Co.								Edgar Thompson Mill							
Broken							33.3% 1	1							2.7% 2	2
Flow of Metal							0	0							0	0
Crushed Head							0%	0							12.3% 9	9
Split Head							33.3% 1	1							76.7% 56	56
Split Web							0%	0							5.5% 4	4
Broken Base							33.3% 1	1							2.7% 2	2
Totals							3	3							73	73

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Lehigh Valley RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 Months ending October 31 1909

Sheet No.

of Sheets

TYPE OF RAIL SECTION

Kind of Failure	Lackawanna Steel Co. Mill															
	90 XXX lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken		8 1				8 1	84 11	13								
Flow of Metal							100 3	3								
Crushed Head	2 2	7 8		2 2		1 1	88 94	107								
Split Head	1						100 25	26								
Split Web							100 7	7								
Broken Base						17 1	83 5	6								
Totals	2 3	6 9		1 2		2 3	89 145	162								
	Carnegie Steel Co. Mill															
Broken				5 1			95 18	19								
Flow of Metal							100 3	3								
Crushed Head							100 14	14								
Split Head							100 21	21								
Split Web							100 15	15								
Broken Base							100 4	4								
Totals				1 1			99 75	76								
	Maryland Steel Co. Mill															
Broken							100 2	2								
Flow of Metal																
Crushed Head							100 3	3								
Split Head	50 1						50 1	2								
Split Web							100 1	1								
Broken Base																
Totals	12 1						88 7	8								

Kind of Failure	Cambria Steel Co. Mill															
	90 XXXlb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken							100 9	9								
Flow of Metal																
Crushed Head							100 5	5								
Split Head							100 2	2								
Split Web							100 1	1								
Broken Base																
Totals							17	17								
	Pennsylvania Steel Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web							100 2	2								
Broken Base																
Totals							100 2	2								
	Bethlehem Steel Co. Mill															
Broken	11 5	4 2	4 2	16 7	5 2		60 27	45								
Flow of Metal																
Crushed Head			18 2	9 1	9 1		64 7	11								
Split Head	12 1	13 1					75 6	8								
Split Web		33 1	33 1				34 1	3								
Broken Base		25 1					75 3	4								
Totals	8 6	7 5	7 5	11 8	4 3		63 47	74								

N.Y.C.& H.R.R.R. RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of ONE YEAR ending OCTOBER 31 1909

Sheet No 89

of ______ Sheets

DUDLEY TYPE OF RAIL SECTION

Kind of Failure	LACKAWANNA STEEL Co. ... Mill															
	100 lb.								80 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	13% 17	10% 13	8% 11	4% 6		1% 1	64% 87	135	9% 5	6% 3	8% 4		4% 2		73% 39	53
Flow of Metal	60% 3		20% 1				20% 1	5								
Crushed Head	17% 8	17% 8	4% 2	2% 1			60% 29	48	9% 1	9% 1				9% 1	73% 8	11
Split Head	25% 56	14% 31	5% 12	3% 7			53% 118	224	25% 5	1% 1					74% 15	21
Split Web	7% 2	10% 3		10% 3	4% 1		69% 20	29							100% 4	4
Broken Base	17% 33	22% 41	21% 40	7% 13			33% 62	189		12% 1					88% 7	8
Totals	19% 119	15% 96	10% 66	5% 30	.1% 1	.1% 1	50.3% 317	630	11% 11	6% 6	4% 4		2% 2	1% 1	76% 73	97

Kind of Failure	CARNEGIE STEEL Co ... Mill															
	100 lb.								80 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken							100% 9	9	1% 1	1% 1					98% 72	74
Flow of Metal							100% 1	1								
Crushed Head							100% 1	1							100% 21	21
Split Head							100% 27	27					.2% 1		99.8% 569	570
Split Web							100% 6	6							100% 119	119
Broken Base			4% 1		4% 1		92% 25	27							100% 8	8
Totals			1% 1		1% 1		98% 69	71	.1% 1	.1% 1			.1% 1		99.7% 789	792

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NORFOLK & WESTERN RY. CO. RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 Months ending Oct. 31st 1909

Sheet No.

A.S.C.E. TYPE OF RAIL SECTION

of Sheets

Kind of Failure	Carnegie Steel Co. Braddock, Pa. Mill																Co. Mill															
	100 lb.								85 lb.								100 lb.								75 ~~85~~ lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken															7	7																
Flow of Metal									1					1 OH	4	5																
Crushed Head									3	2					16	21																
Split Head									3		1				30	34																
Split Web															1	1																
Broken Base															1	1																
Totals									7	2	1			1	59	69																
	Maryland Steel Co. Sparrows Point, Md. Mill																Co. 75# Mill															
Broken																																
Flow of Metal																																
Crushed Head															13	13															2	2
Split Head													1			1															4	4
Split Web															1	1																
Broken Base																																
Totals													1		14	15															6	6
	Cambria Steel Co. Johnstown, Pa. Mill																Co. Mill															
Broken															2	2																
Flow of Metal													OH 2			2																
Crushed Head															2	2																
Split Head										1					2	3																
Split Web										OH 1			1		1	3																
Broken Base																																
Totals										2			3		7	12																

91

NORTHERN PACIFIC RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six Months **ending** October 31st, 19 09.

Sheet No. 3 of 3 Sheets

A.S.C.E. TYPE OF RAIL SECTION

Kind of Failure	Carnegie Steel Co. Mill																Co. Mill															
	100 lb.								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken									1						7	8																
Flow of Metal																																
Crushed Head																																
Split Head															1	1																
Split Web																																
Broken Base															1	1																
Totals									1						9	10																
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																

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NORTHERN PACIFIC RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six Months **ending** October 31st, 19 09.

Sheet No. 2 of 3 Sheets

A.S.C.E. TYPE OF RAIL SECTION

Kind of Failure	Illinois Steel Co. Mill																Co. Mill															
	72 XXXXlb.								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken							16	16	1	3	1				76	81																
Flow of Metal							4	4							13	13																
Crushed Head							5	5	2						73	75																
Split Head							7	7	2	1	1				45	49																
Split Web							2	2	1	1					8	10																
Broken Base							2	2	1		2				85	88																
Totals							36	36	7	5	4				300	316																
	Lackawanna Steel Co. Mill																Co. Mill															
Broken							3	3				1			10	11																
Flow of Metal							1	1																								
Crushed Head							6	6	3	8	7				15	33																
Split Head									2	7					10	19																
Split Web							1	1																								
Broken Base							2	2		1				1	40	42																
Totals							13	13	5	16	7	1		1	75	105																
	Lorain Steel Co. Mill																Co. Mill															
Broken															1	1																
Flow of Metal							1	1																								
Crushed Head							1	1																								
Split Head							2	2																								
Split Web																																
Broken Base																																
Totals							4	4							1	1																

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NORTHERN PACIFIC RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six Months **ending** October 31st, 1902.

Sheet No. 1

of 3 Sheets

A. R. A. TYPE OF RAIL SECTION

Kind of Failure	Illinois Steel Co. Open Hearth Type B. ~~Mill~~																Co. Mill															
	90 XXX lb.								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken							1	1																								
Flow of Metal							1	1																								
Crushed Head																																
Split Head																																
Split Web																																
Broken Base							1	1																								
Totals							3	3																								
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																

Pennsylvania Railroad- Lines East RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 months **ending** October 31 1909

P.R.R. TYPE OF RAIL SECTION

Sheet No 1

of 4 Sheets

Kind of Failure	Cambria Co. Johnstown Mill																Carnegie Co. Edgar Thompson Mill															
	100 lb.								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken							47	47							19	19							20	20							24	24
Flow of Metal							8	8															9	9							1	1
Crushed Head							6	6							1	1							10	10							30	30
Split Head							28	28							3	3							22	22							54	54
Split Web							43	43							7	7							19	19							11	11
Broken Base							2	2							7	7							2	2							6	6
Totals							134	134							37	37							82	82							126	126
	Lackawanna Co. Buffalo Mill																Maryland Co. Sparrows Point Mill															
Broken															24	24	2	1	1				26	30							15	15
Flow of Metal															1	1																
Crushed Head															8	8							13	13							9	9
Split Head															12	12							6	6							7	7
Split Web															2	2		5	2	1			44	52							10	10
Broken Base															29	29							2	2							3	3
Totals															76	76	2	6	3	1			91	103							44	44
	Pennsylvania Co. Steelton Mill																Carnegie (Nickel Steel) Co. Edgar Thompson Mill															
Broken							8	8							5	5																
Flow of Metal							1	1							2	2																
Crushed Head							1	1							7	7							1	1								
Split Head							2	2							6	6							4	4								
Split Web							14	14							7	7							1	1								
Broken Base							2	2							1	1																
Totals							28	28							28	28							6	6								

Pennsylvania Railroad - Lines East RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 months **ending** October 31 1909

Sheet No. 2
of 4 Sheets

P.R.R. TYPE OF RAIL SECTION

Kind of Failure	Joliet (Rerolled Rail) Co.								Joliet Mill								Pennsylvania (Open Hearth) Co.								Steelton Mill							
	100 lb.								84 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken															1	1			1				1	2								
Flow of Metal																																
Crushed Head																																
Split Head															3	3							1	1								
Split Web																			1				1	2								
Broken Base																																
Totals															4	4			2				3	5								
	Co.								Mill								Co.								Mill							
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	Co.								Mill								Co.								Mill							
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																

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Pennsylvania Railroad - Lines East RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 months ending October 31 1909

Sheet No. 3 of 4 Sheets

P. S. TYPE OF RAIL SECTION

Kind of Failure	Cambria Co. Johnstown Mill															
	100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	1		1					2					1			1
Flow of Metal	1			1	1			3					1			1
Crushed Head	5	1		1				7								
Split Head	8	3			2			13				1				1
Split Web	1							1	1		1	1	4			7
Broken Base																
Totals	16	4	1	2	3			26	1		1	2	6			10

Kind of Failure	Bethlehem Co. Bethlehem Mill															
	100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																
Flow of Metal														1		1
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals														1		1

	Cambria (Open Hearth) Co. Johnstown Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head		1						1								
Split Web																
Broken Base																
Totals		1						1								

	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

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Pennsylvania Railroad- Lines East RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 months **ending** October 31 1909

Sheet No. 4 of 4 Sheets

A.S.C.E. TYPE OF RAIL SECTION

Kind of Failure	Cambria Co. Johnstown Mill																Pennsylvania Co. Steelton Mill															
	100 lb.								80 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken															1	1																
Flow of Metal																																
Crushed Head																																
Split Head															3	3																
Split Web															1	1															2	2
Broken Base																																
Totals															5	5															2	2
	Carnegie Co. Edgar Thompson Mill																Co. Mill															
Broken															2	2																
Flow of Metal																																
Crushed Head																																
Split Head															4	4																
Split Web																																
Broken Base																																
Totals															6	6																
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																

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PENNSYLVANIA LINES WEST of PITTSBURGH – N.W. SYSTEM RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six Months ending Oct. 31 1909

Sheet No. 2
of 2 Sheets

A.R.A."A" & P.S. TYPE OF RAIL SECTION

Kind of Failure	MARYLAND STEEL Co. BESSEMER STEEL – SPARROWS PT. Mill															
	100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	G*	Unknown	Total
Broken																
Flow of Metal									1							1
Crushed Head																
Split Head									1							1
Split Web																
Broken Base																
Totals								–	2							2
	CAMBRIA STEEL Co. BESSEMER STEEL – JOHNSTOWN Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head									1					1		2
Split Web																
Broken Base																
Totals								–	1					1		2
	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

Kind of Failure	A.R.A. TYPE "A" – CARNEGIE Co. BESSEMER STEEL E.T. Mill															
	100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base							1	1								
Totals							1	1								–
	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																
	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

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PENNSYLVANIA LINES WEST of PITTSBURGH-N.W. SYSTEM RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six Months ending Oct. 31 1909

Sheet No. 1 of 2 Sheets

P. S. TYPE OF RAIL SECTION

Kind of Failure	Carnegie Steel Co. Bessemer Steel E. T. Mill																Illinois Steel Co. Bessemer, So. Chicago Mill															
	100 lb.								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	J#	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken		2	1					3			1					1																
Flow of Metal			1					1	3		2					5																
Crushed Head									17	1	20	2				40																
Split Head		1						1	9		11				1	21																
Split Web									1		3					4																
Broken Base																								–								–
Totals		3	2					5	30	1	37	2			1	71																
	Carnegie Steel Co. Open Hearth - Class A - E. T. Mill																Illinois Steel Co. Co. Open Hearth, Class A, Gary Mill															
Broken																	1	3						4								
Flow of Metal																					1			1								
Crushed Head																					1	1		2								
Split Head							1	1						1		1						1		1								
Split Web																																
Broken Base																																–
Totals							1	1						1		1	1	3			2	2		8								
	Carnegie Steel Co. Open Hearth - Class B - E. T. Mill																Illinois Steel Co. Open Hearth, Class B, Gary Mill															
Broken																																
Flow of Metal																																
Crushed Head																					1			1								
Split Head																																
Split Web																																
Broken Base																–																
Totals								–													1			1								–

100

Pennsylvania Lines West of Pittsburgh. (South-West System) RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of 6 Months ending Oct. 31 1909

ARA & P.S. TYPE OF RAIL SECTION

Sheet No. 1

of 1 Sheets

Kind of Failure	Carnegie Steel Co. Bessemer Steel. E. Thompson Mill															
	100 lb. P.S. Sec.								85 lb. P.S. Sec.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken									1							1
Flow of Metal																
Crushed Head		3						3	4		5				3	12
Split Head									3		5				1	9
Split Web																
Broken Base																
Totals		3						3	8		10				4	22
	ARA Sec. Carnegie Steel Co. Bessemer Steel. E. Thompson Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head	1							1								
Split Web																
Broken Base																
Totals	1							1								
	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

Kind of Failure	Illinois Steel Co. 85 lb. Open Hearth. Gary. Mill															
	100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken									1							1
Flow of Metal										1						1
Crushed Head																
Split Head																
Split Web									1							1
Broken Base									1							1
Totals									3	1						4
	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																
	Co. Mill															
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

101

Philadelphia and Reading RAILROAD

Sheet No._____ of_____ Sheets

Position in Ingot of Steel Rails which Failed, for Period of 6 Months ending October 31, 1909

A.S.C.E. TYPE OF RAIL SECTION

Kind of Failure	Maryland Steel Co.															Mill
	90 ~~100~~ lb.								86 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken	4	5	1	4	2		8	24								
Flow of Metal	60	45	34	27	19		7	192								
Crushed Head	23	12	17	15	12		14	93								
Split Head	14	1	0	1	0		7	23								
Split Web	0	1	1	0	1		2	5								
Broken Base	0	2	2	2	3		0	9								
Totals	101	66	55	49	37		38	346								
	Cambria Steel Co.															Mill
Broken							1	1								
Flow of Metal							1	1								
Crushed Head							0	0								
Split Head							4	4								
Split Web							0	0								
Broken Base							0	0								
Totals							6	6								
	Carnegie Steel Co.															Mill
Broken							3	3								
Flow of Metal							0	0								
Crushed Head							1	1								
Split Head							3	3								
Split Web							1	1								
Broken Base							0	0								
Totals							8	8								

Kind of Failure	Lackawanna Steel Co.															Mill
	90 ~~100~~ lb.								86 lb.							
	A	B	C	D	E	F.	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken							0	0								
Flow of Metal							3	3								
Crushed Head							2	2								
Split Head							3	3								
Split Web							0	0								
Broken Base							0	0								
Totals							8	8								
	Pennsylvania Steel Co.															Mill
Broken							3	3								
Flow of Metal							0	0								
Crushed Head							0	0								
Split Head							0	0								
Split Web							0	0								
Broken Base							0	0								
Totals							3	3								
	Co.															Mill
Broken																
Flow of Metal																
Crushed Head																
Split Head																
Split Web																
Broken Base																
Totals																

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TOLEDO AND OHIO CENTRAL RAILROAD

Position in Ingot of Steel Rails which Failed, for Period of Six (6) months ending October 31st, 1909.

Sheet No. –

Dudley TYPE OF RAIL SECTION

of Sheets

Kind of Failure	Carnegie Steel Co. Bessemer Mill																Co. Mill															
	100 lb.								80 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																																
Flow of Metal																																
Crushed Head									3							3																
Split Head									3							3																
Split Web																																
Broken Base																																
Totals									6							6																
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	Co. Mill																Co. Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																

Boston and Albany RAILROAD *103*

Record of Comparative Wear of Special Rail

Date of Report *October 31,* 19*09*

Special Rail													Chemical Composition of *100 lb.* Rail of *Dudley (N.Y.C. Type)* Section with which Special Rail was Compared							Special and Comparative Rails						
Kind of Steel	Location	No. of Tons Laid	Weight per Yard	Type of Section	Manufacturer	Chemical Composition														Date Laid	Date Removed	Length of Service at date of Report	Average Area Abraded of all the Sections taken			
																							Special		Comparative	
						C	P	Mn	Si	S	*Ft*		C	P	Mn	Si	S						Sq. In. abraded	% of area of Head	Sq. In. abraded	% of area of Head
Bessemer	*East Brookfield*	—	*100*	*Dudley Sec. NYC Type*	*L. S. Co.*	*0.48*	*0.096*	*1.00*	*0.13*	*0.06*	*0.02*	—	*0.50*	*0.096*	*1.00*	*0.13*	*0.08*	—	—	*Oct. 1 '08*	—	*13 mos.*	*No record taken to date.*			
"	*Chatham Centre*		"	"	"	"	"	"	"	"			"	"	"	"	"			"		"	"	"	"	"

1m 1-27-09

Form 168 Spl.

THE BALTIMORE & OHIO RAILROAD CO.

~~THE BALTIMORE & OHIO SOUTHWESTERN RAILROAD CO~~

MAINTENANCE OF WAY DEPARTMENT.

.... Division

Record of Comparative Wear of Special Rail.

Date of Report October 31st., 19 09 104

Special Rail													Chemical Composition								Special and Comparitive Rail.						
Kind of Steel.	Location	Number of Tons Laid. in Test	Weight per Yard.	Type of Section	Manufacturer	Chemical Composition.							of Md.Steel Co. BESSEMER Rail of A.S.C.E. Section with which Special Rail was compared.							Date Laid.	Date Removed	Last Inspection Length of Service at Date of Report	Average Area Abraded of all the Sections taken.			
																							Special		Comparitive	
						C.	P.	Mn.	Si.	S.	N	Tita.	C.	P	Mn.	Si.	S.						Sq.in. Abraded	% of area of Head	Sq in. Abraded	% of area of Head.
	Kosslers Curve																						HR.250	HR 5.6	HR.626	HR15.8
Titanium	9° Cumb'd Div.	7.9	100#	ASCE	Md.Steel Co	.701	.086	.92	.079	.045	.004	1-½%	.54	.069	1.01	.074	.073			Oct. 10, 1906.	In Trk	12 mo.	LR.097	LR 2.3	LR.409	LR10.0
Alloy	E.E. Heavy																									
	Traffic																									
																	BESSEMER									
Bessemer	E.of Hollofield.										Or.		CAMBRIA	STEEL		CO.	A.S.C.E.	RAIL					HR.569	HR15.6	HR.401	HR12.1
Special Rail	Md.-Balto.Div.	7.95	85#	ASCE	Pa.Steel Co	.472	.024	.79		.062	.21		.505	.0975	.945	.066	.0625			Aug. 17 1906		28 mo.	LR.253	LR 7.5	LR.293	LR 8.8
																	BESSEMER									
	E.of Union Dam												CARNEGIE	STEEL		CO.	A.S.C.E.	RAIL					HR.298	HR 5.1	HR.264	HR6.6
Bessemer	Tunnel	12.93	85#	ASCE	Pa.Steel Co	.472	.024	.79		.062	.21		.485	.095	.95	.20	.047			Sep. 17, 1908		22 mo.	LR.112	LR 3.3	LR.216	LR6.4
	Balto. Division																									
Bessemer	E.of Union Dam																BESSEMER									
	Tunnel												CAMBRIA	STEEL		CO.	A.S.C.E.	RAIL					HR.298	HR5.1	HR.382	HR11.5
	Balto. Division	12.83	85#	ASCE		.472	.024	.79		.062	.21		.505	.0975	.945	.066	.0625			Sept. 17 1908		22 mo.	LR.112	LR3.6	LR.131	LR5.9

105

GEORGIA RAILROAD

Record of Comparative Wear of Special Rail

Date of Report November 9, 1909

Special Rail													Chemical Composition of ......Rail of ......Section with which Special Rail was Compared							Special and Comparative Rails						
Kind of Steel	Location	No. of Tons Laid	Weight per Yard	Type of Section	Manufacturer	Chemical Composition														Date Laid	Date Removed	Length of Service at date of Report	Average Area Abraded of all the Sections taken			
																							Special		Comparative	
						C	P	Mn	Si	S			C	P	Mn	Si	S						Sq. In. abraded	% of area of Head	Sq. In. abraded	% of area of Head
Open Hearth	Main Line	2,000	80#	ACSE	TCIARRCo	.57	.033	.97	008	048			.63	.049	1.00	.008	.047			1908		1.8yr	.120	50	0.0	0.0

106

LEHIGH VALLEY RAILROAD

Record of Comparative Wear of Special Rail

Date of Report October 31, 1909

Special Rail													Chemical Composition of ....Rail of ....Section with which Special Rail was Compared							Special and Comparative Rails						
Kind of Steel	Location	No. of Tons Laid	Weight per Yard	Type of Section	Manufacturer	Chemical Composition														Date Laid	Date Removed	Length of Service at date of Report	Average Area Abraded of all the Sections taken			
																							Special		Comparative	
						C	P	Mn	Si	S	Ni.	Chr	C	P	Mn	Si	S						Sq. In. abraded	% of area of Head	Sq. In. abraded	% of area of Head
Open Hearth	MP 186-900'	4093	90#	ACSE	Bethlehem	.50% .60%	.04%	.60% .90%	.20%		2%	.40% .75%								4-09	9-09					
" "	" 179-4200'		"	"	Steel Co.	"	"	"	"		"	"								7-09	9-09					
" "	" 173-3566'		"	"	"	"	"	"	"		"	"								8-09	9-09					
" "	" 173-3500'		"	"	"	"	"	"	"		"	"								8-09	9-09					
" "	" 53-2970'		"	"	"	"	"	"	"		"	"								8-09	8-09					
" "	" 135-4797'		"	"	"	"	"	"	"		"	"								3-09	8-09					

Norfolk & Western Ry. RAILROAD

107

Record of Comparative Wear of Special Rail

Date of Report *Jan. 10th.* 19*10*
as of Oct. 31, 1909

Special Rail													Chemical Composition of *Carnegie Bessemer* Rail of *85 lb. A.S.C.E.* Section with which Special Rail was Compared *on same Curve*							Special and Comparative Rails						
Kind of Steel	Location	No. of Tons Laid	Weight per Yard	Type of Section	Manufacturer	Chemical Composition														Date Laid	Date Removed	Length of Service at date of Report	Average Area Abraded of all the Sections taken			
																							Special		Comparative	
						C	P	Mn	Si	S			C	P	Mn	Si	S						Sq. In. abraded	% of area of Head	Sq. In. abraded	% of area of Head
Manganese	*Glen Lyn*	*4*	*85*	*A.S.C.E*	*Manganese*	*.77*	*.06*	*9.93*	*.25*	*.038*										*Apr. 09.*	*Test in progress*	*7 Mo.*	*0.127*	*3.6*		
	M.P. 340.2				*Steel Co.*																*10-31-09.*					
	on high side																									
	of 9° Curve																									
	E.B. Track																									
													49	*.093*	*.90*	*.10*	*.04*			*Apr. 1. 09.*	*Test in progress* *10-31-09*	*7 Mo.*			*0.29*	*8.4*

Approx gross tonnage over Rails, 8 Mil. Tons.

Norfolk & Western Ry. RAILROAD

Record of Comparative Wear of Special Rail

Date of Report Jan. 10th. 1910
As of Oct. 31, 1909

Special Rail													Chemical Composition of Cambria-Bessemer Rail of 85 lb. A.S.C.E. Section with which Special Rail was Compared on same Curve							Special and Comparative Rails							
Kind of Steel	Location	No. of Tons Laid	Weight per Yard	Type of Section	Manufacturer	Chemical Composition														Date Laid	Date Removed	Length of Service at date of Report	Average Area Abraded of all the Sections taken				
																							Special		Comparative		
						C	P	Mn	Si	S	Chromium		C	P	Mn	Si	S						Sq. In. abraded	% of area of Head	Sq. In. abraded	% of area of Head	
Chrome Steel	Near Christiansburg	18	85	A.S.C.E.	Maryland	.38	.016	.73		.069	.24									July '07	July '09	24 Mo.	H. 0.78	22			Approx. gross tonnage over Rails 24 Mil. Tons
called Mayari	M.P. 293																						L. 0.94	27			
	on both sides of																										
	7°30' Curve																										
	E.B. Track																										
													.52	.097	.86	.085	.05			Dec '06	Sept '08	21 Mo.			H. 1.02	29	Approx. gross tonnage over Rails 21 Mil. Tons.
																									L. 0.88	25	

Note—
No appreciable difference in the shape of worn heads of Mayari and Bessemer Rails tested.

Pennsylvania (Lines East) RAILROAD

Record of Comparative Wear of Special Rail

Date of Report October 31 1909

Special Rail													Chemical Composition of Open Hearth Rail of P.R.R. Section with which Special Rail was Compared							Special and Comparative Rails						
Kind of Steel	Location	No. of Tons Laid	Weight per Yard	Type of Section	Manufacturer	Chemical Composition														Date Laid	Date Removed	Length of Service at date of Report	Average Area Abraded of all the Sections taken			
																							Special		Comparative	
						C	P	Mn	Si	S	Ni		C	P	Mn	Si	S						Sq. in. abraded	% of area of Head	Sq. in. abraded	% of area of Head
Nickel	Phila. Term. Div. W.B.P. 52nd St. Yard	2.32	100	P.R.R.	Carnegie	.51	.092	.84	.11	.046	3.25									4-04	9-07	3y. 5m	.63	14.0	—	—
Mayari	Middle Div. E.B.P. E. of S.C. Tunnel	21.16	"	"	Maryland	.462	.008	.680	—	.060			.434	.008	.820	—	.050			4-06	8-09	3y. 4m.	.55	12.1	.63	13.9
Remlled Bess	E.B.P. Warrior Ridge	53.62	84	Special	Joliet	.50	.08	1.00	.13	—										5-07	8-09	2y. 3m.	.27	7.6	—	—
Bessemer	E.B.P. E. of Birmingham	124.15	100	P.S.	Cambria #2	"	"	"	"											9-08	8-09	0y. 11m	.97	23.7	—	—

Pennsylvania Lines West of Pittsburgh South-West System Pittsburgh Div'n. RAILROAD

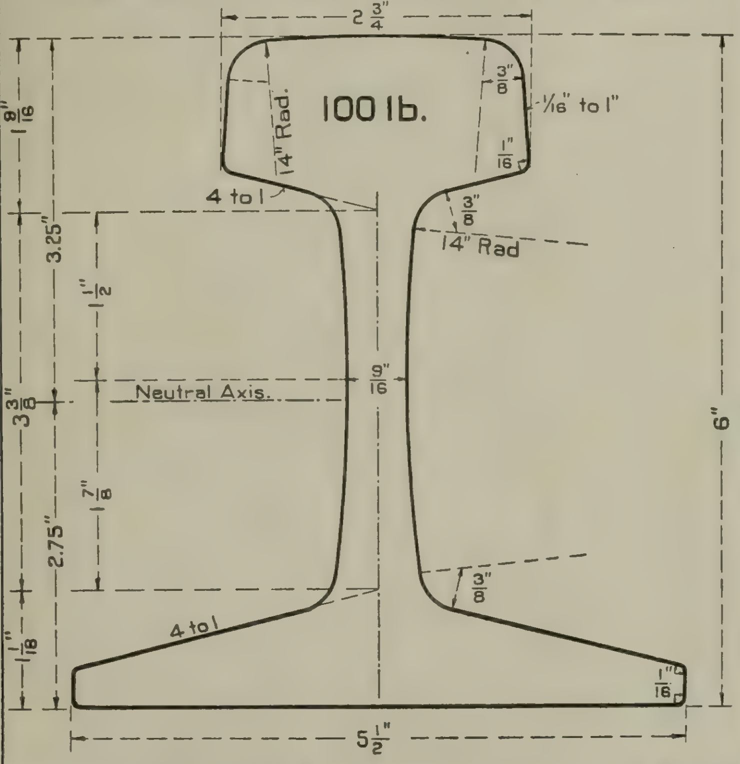
Record of Comparative Wear of Special Rail

Date of Report April 1909

Special Rail												Chemical Composition of 85 lb. Carnegie Bessemer Rail of A.S.C.E. Section with which Special Rail was Compared					Special and Comparative Rails						
Kind of Steel	Location	No. of Tons Laid	Weight per Yard	Type of Section	Manufacturer	Chemical Composition											Date Laid	Date Removed	Length of Service at date of Report	Average Area Abraded of all the Sections taken			
																				Special		Comparative	
						C	P	Mn	Si	S	Ni.	C	P	Mn	Si	S				Sq. in. abraded	% of area of Head	Sq. in. abraded	% of area of Head
Nickel	Oakdale to McDonald	363	85	A.S.C.E.	Carnegie	.441	.092	.76	.089	.029	3.40	.490	.097	.96	.108	.035	May '03	Mar. '06	2 Yrs. 10 Mo.			.33	9.4
																		Oct. '07	4 " 5 "	.26	7.4	.41	11.7
																		Oct. '08	5 " 5 "	.36	10.03	.35	10.0
																		Apr. '09	5 " 11 "	.41	11.7	.53	15.1
Nickel	Hanlin to Collier	736	85	A.S.C.E.	Carnegie	.430	.090	.80	.093	.030	3.42	.498	.093	.85	.105	.038	May '03	Mar. '06	2 " 10 "	.49	14.1	.55	15.7
																		June '06	3 " 1 "	.41	11.7	.48	13.8
																		Mar. '07	3 " 10 "	.44	12.3	.58	16.5
Nickel	Wheeling Jct.	104	85	A.S.C.E.	Carnegie	.431	.087	.84	.089	.030	3.45	.520	.097	1.00	.105	.031	May '03	May '06	3 " 0 "	.41	11.7	.53	15.1
Nickel	Cadiz Jct.	109	85	A.S.C.E.	Carnegie	.447	.090	.79	.077	.029	3.39	.480	.092	.84	.105	.038	May '03	Oct. '07	4 " 5 "	.35	10.0	.86	24.6
																		Oct. '08	5 " 5 "	.73	20.9		
Nickel	BA Tower to Scio	168	85	A.S.C.E.	Carnegie	.433	.092	.76	.092	.029	3.50	.460	.094	.88	.105	.043	May '03	May '09	6 " 0 "	.41	11.7	.45	13.0
	Average for Pgh. Div.																In Service		4 Yrs. 1.7 Mo.	.433	12.38%		
Nickel	Pitts. Div.		85	A.S.C.E.	Carnegie	.433	.090	0.80	.090	.030	3.44	.490	.095	.91	.106	.037	"	"	4 " 2.3 "			.519	14.89%

AMERICAN RAILWAY ASSOCIATION.

Standard A.R.A. Rail Section. Type A.

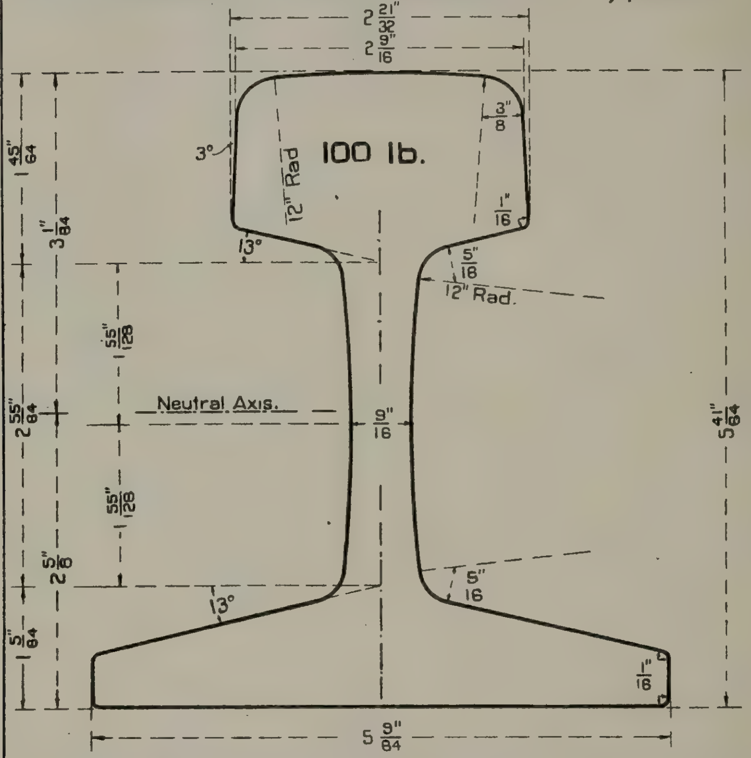


Area of Head-3.64 sq. in-36.9 % Ratio Periphery of Head to Area of Head-1.80
• • Web-2.29 • -23.4 • • • Web • Web-3.21
• • Base-3.91 • -39.7 • • • Base • Base-3.29
• Total-9.84 • -100 • • Total Periphery to Total Area -2.92

Moment of Inertia -48.94
Section Modulus, Head -15.04
• • Base -17.78

AMERICAN RAILWAY ASSOCIATION.

Standard A.R.A. Rail Section. Type B.

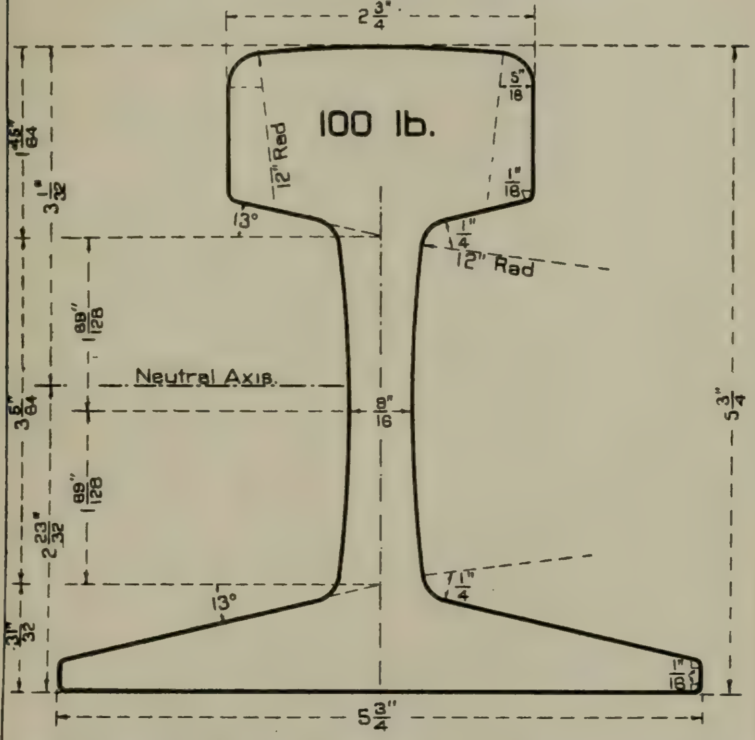


Area of Head - 3.95 sq. in. - 40.2 %	Ratio Periphery of Head to Area of Head - 1.64
" " Web - 1.89 " - 19.2 "	" " Web " Web - 3.60
" " Base - 4.01 " - 40.6 "	" " Base " Base - 2.49
" Total - 9.85 " - 100 "	" Total Periphery to Total Area - 2.37

Moment of Inertia - 41.3
Section Modulus, Head - 13.70
" " Base - 15.74

AMERICAN SOCIETY OF CIVIL ENGINEERS.

Standard A.S.C.E Rail Section.

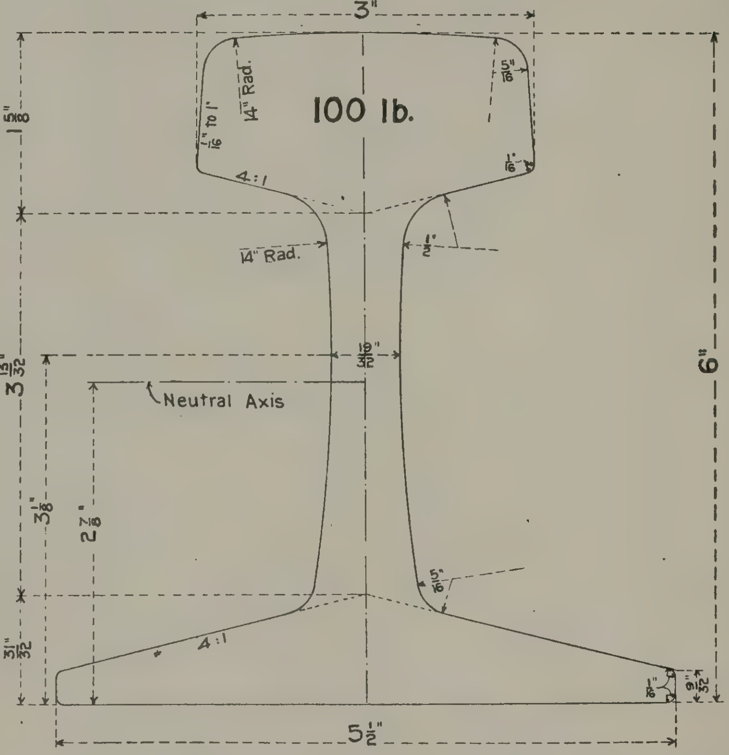


Area of Head	4.13 sq. in.	42 %	Ratio Periphery of Head to Area of Head	1656
" " Web	2.06 "	21 "	" " " Web "	Web	3433
" " Base	3.63 "	37 "	" " " Base "	Base	3.057
" " Total	9.82 "	100 "	" Total Periphery to Total Area		2.549

Moment of Inertia - 43.80
Section Modulus, Head - 14.44
" " Base - 16.11

NEW YORK CENTRAL LINES

Dudley Rail Section

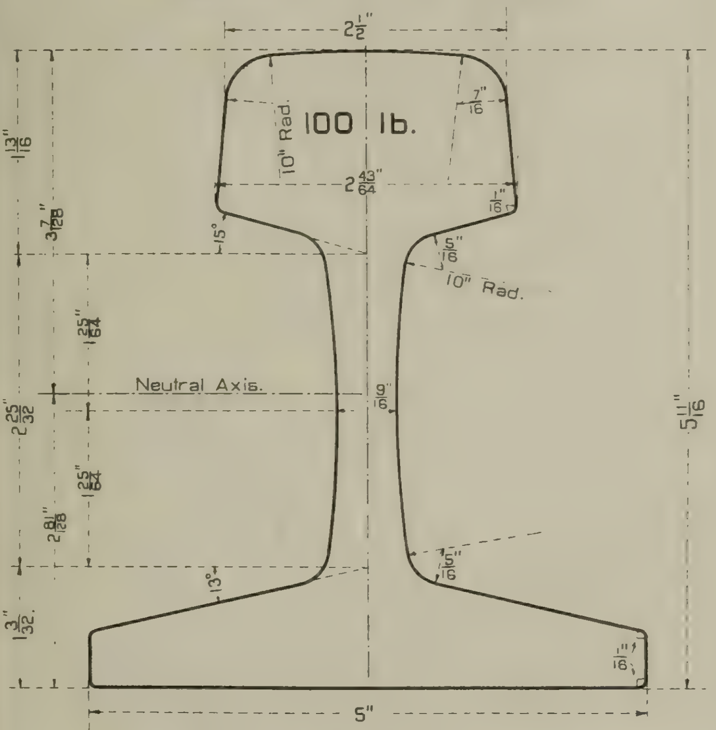


Area of Head = 4.16 sq. in. = 41.5%. Ratio Periphery of Head to Area of Head = 1.89
" " Web = 2.31 " = 23.1 ". " " " Web " " " Web = 4.73
" " Base = 3.55 " = 35.4 ". " " " Base " " " Base = 3.25
" " Total = 10.02 " = 100.0 ". " Total Periphery to Total Area = 2.42

Moment of Inertia = 49.0
Section Modulus, Head = 15.69
" " Base = 17.00

PENNSYLVANIA RAILROAD SYSTEM.

Standard **P. S.** Rail Section.

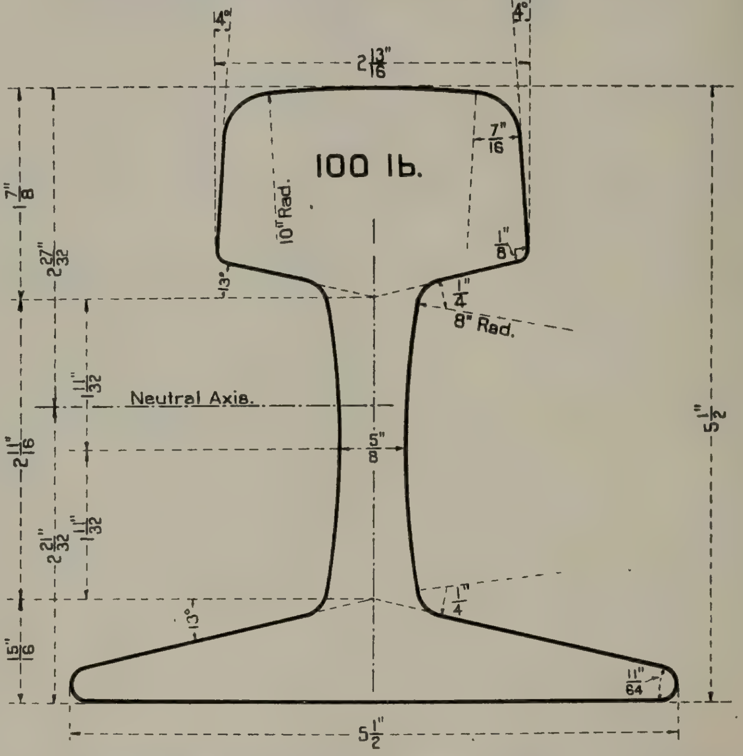


Area of Head = 4.09 sq.in. = 41.0% Ratio Periphery of Head to Area of Head = 1.59
" " Web = 1.85 " = 18.6 " " " " Web " " " Web = 3.58
" " Base = 4.03 " = 40.4 " " " " Base " " " Base = 2.43
" " Total = 9.97 " = 100.0 " " Total Periphery to Total Area = 2.30

Moment of Inertia = 41.9
Section Modulus, Head = 13.71
" " Base = 15.91

PENNSYLVANIA RAILROAD.

Former Standard P.R.R. Rail Section.

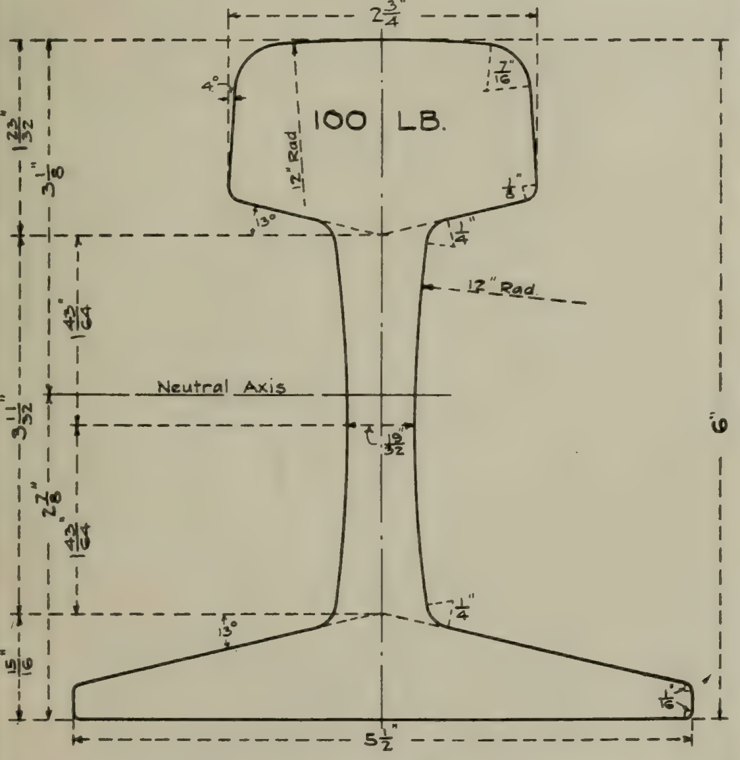


Area of Head = 4.512 sq. in. = 45.7%. Ratio Periphery of Head to Area of Head = 1.52
" " Web = 1.986 " = 20.11 " " " " Web " " " Web = 3.17
" " Base = 3.378 " = 34.2 " " " " Base " " " Base = 3.04
" " Total = 9.876 " = 100.0 " " Total Periphery to Total Area = 2.37

Moment of Inertia, = 37.956
Section Modulus, Head, = 13.35
" " Base, = 14.29

N. Y. N. H. & H. R. R.

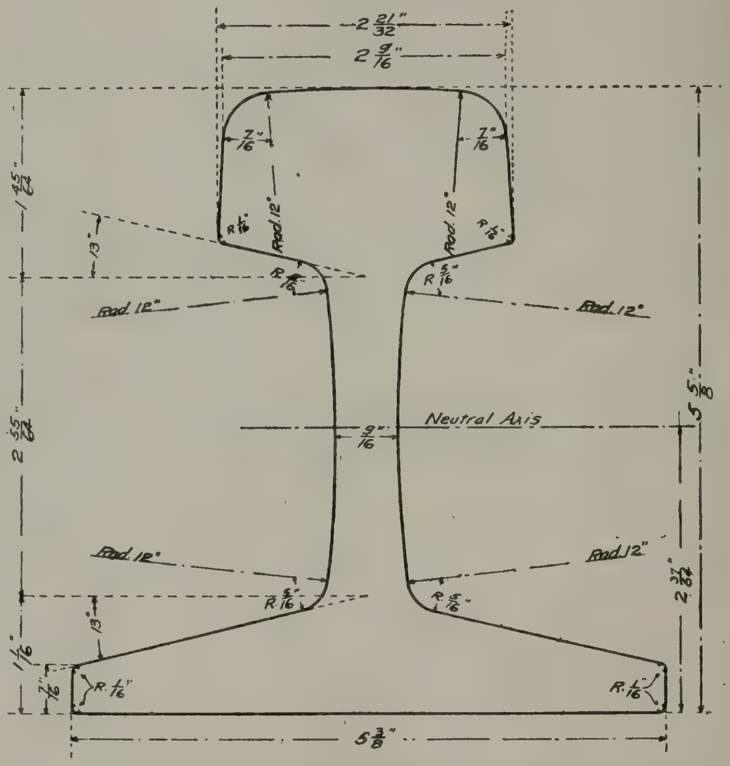
STANDARD RAIL SECTION.



Area of Head = 4.04 sq.in = 41 % } Ratio Periphery of Head to Area of Head 1.93
" " Web = 2.33 " = 24 " " " " Web " " " Web 4.29
" " Base 3.40 " = 35 " " " " Base " " " Base 3.45
" " Total 9.77 " = 100 " " Total Periphery to Total Area 2.53

Moment of Inertia = 47.18
Section Modulus, Head = 15.10
" " Base = 16.41

—PHILADELPHIA & READING RAILWAY—
100 LB. RAIL SECTION
Scale – Full Size



Area of Head	3.94 sq. in	40.04 per cent
" " Web	1.89 " "	19.21 " "
" " Base	4.01 " "	40.75 " "
Total	9.84 " "	100.00 " "

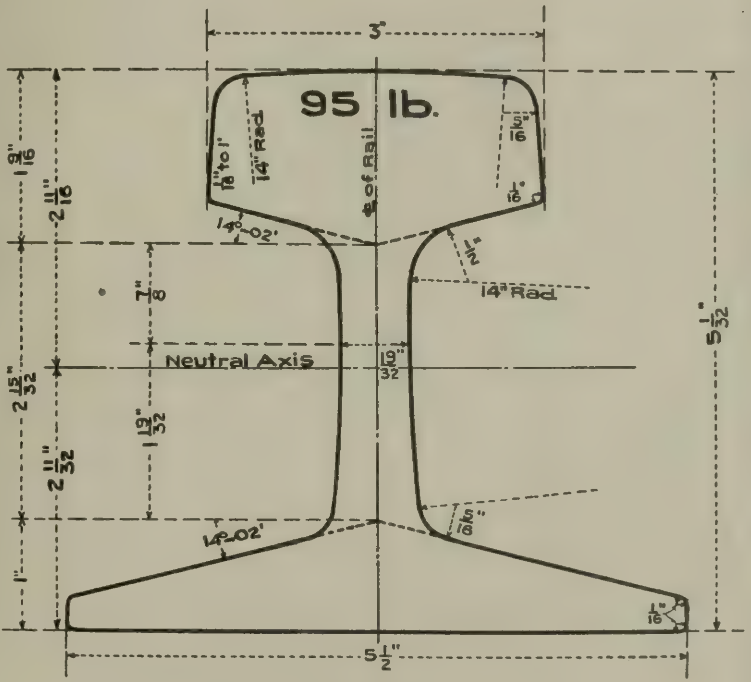
Moment of Inertia = 41.43
Section Modulus, Head = 13.61
" " , Base = 16.06

5-11-19

BOSTON & ALBANY R.R.

N.Y.C. & H.R.R.R. Co. LESSEE.

STANDARD 95 LB. RAIL SECTION.



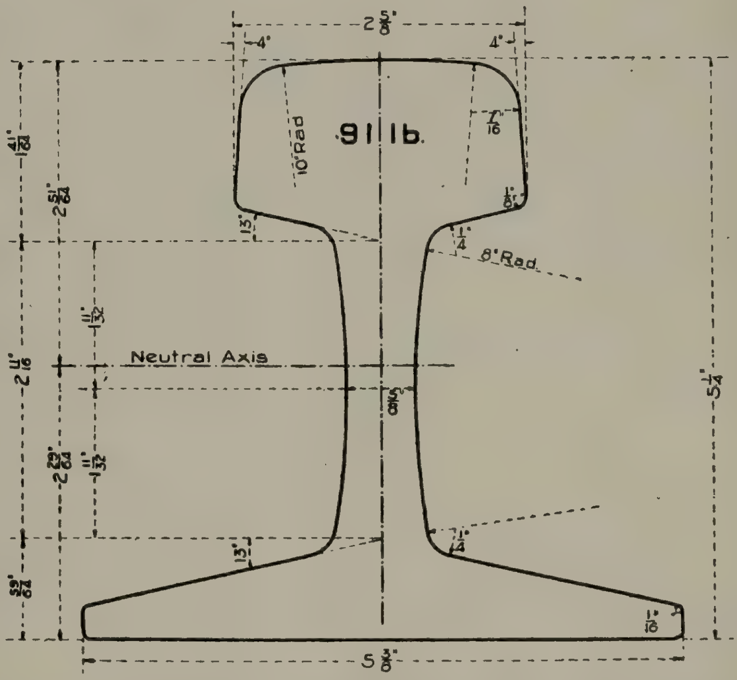
Area of Head = 3.94 sq. in. = 42.1 %. Ratio Periphery of Head to Area of Head = 2.03
" " Web = 1.80 " = 19.3 " . " " " Web " " " Web = 4.95
" " Base = 3.61 " = 38.6 " " " " Base " " " Base = 3.24
" " Total = 9.35 " = 100.0 " . " Total Periphery to Total Area. = 2.47

Moment of Inertia = 31.36
Section Modulus, Head = 11.65
" " Base = 13.40

L.M.H. - B.S.R.

LACKAWANNA RAILROAD.

Standard D.L.&W. Rail Section

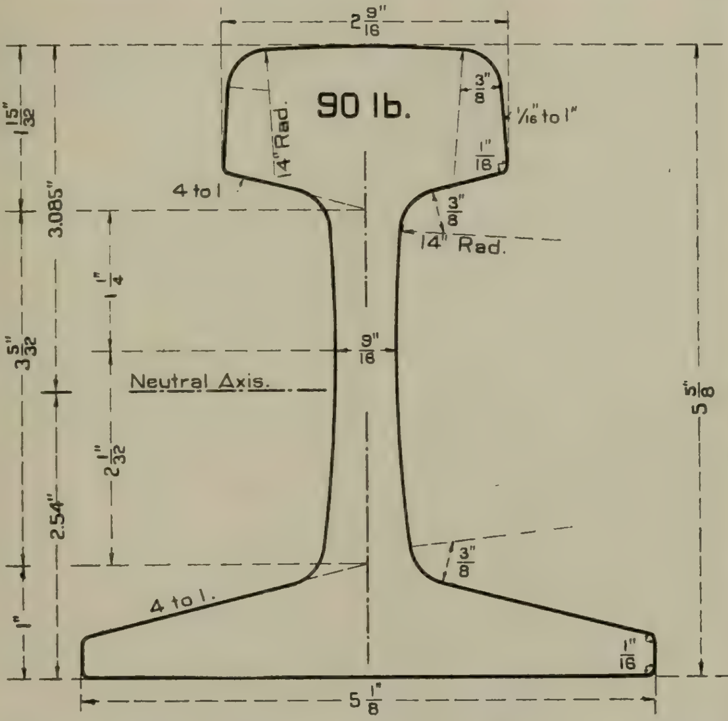


Area of Head = 3.70 sq in = 41.5%. Ratio Periphery of Head in Area of Head = 1.63
" " Web = 1.93 " " = 21.7. " " " Web " " " Web = 3.27
" " Base = 3.28 " " = 36.8. " " " Base " " " Base = 3.09
" " Total = 8.91 " " = 100.0% " Total Periphery in Total Area = 2.52

Moment of Inertia = 31.65
Section Modulus, Head = 11.32
" " Base = 12.90

AMERICAN RAILWAY ASSOCIATION.

Standard A.R.A. Rail Section. Type A.

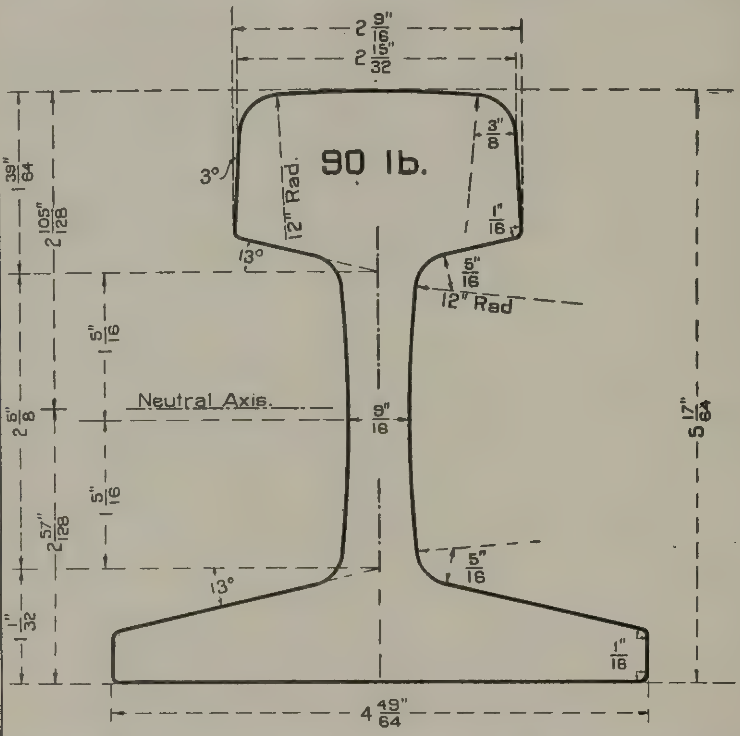


Area of Head - 3.20 sq in - 36.2 % Ratio Periphery of Head to Area of Head - 1.90
" " Web - 2.12 " - 24.0 " " " Web " Web - 3.30
" " Base - 3.50 " - 39.8 " " " Base " Base - 2.63
" Total - 8.82 " = 100 " " Total Periphery to Total Area = 2.52

Moment of Inertia = 38.7
Section Modulus, Head = 12.56
" " Base = 15.23

AMERICAN RAILWAY ASSOCIATION.

Standard A.R.A. Rail Section. Type B.

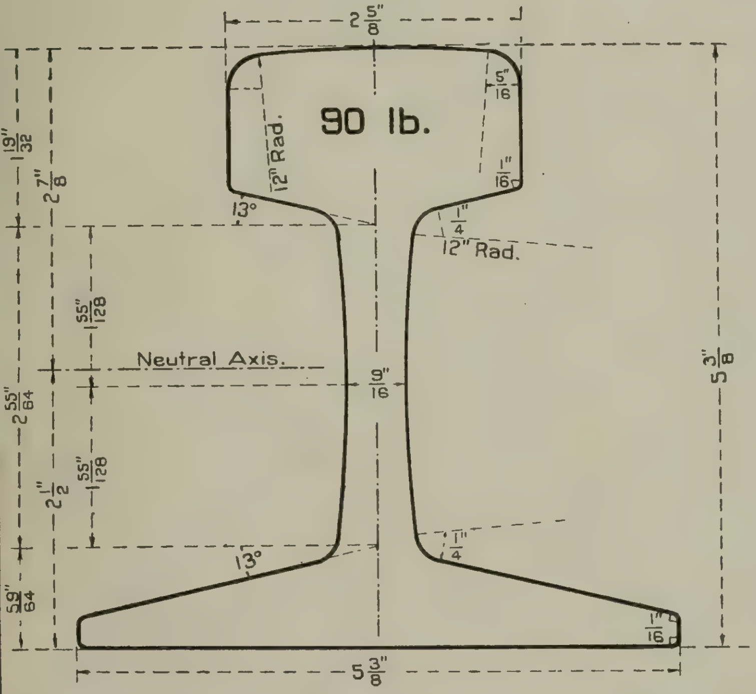


Area of Head = 3.56 sq. in. = 40.1 % Ratio Periphery of Head to Area of Head = 1.68
" " Web = 1.70 " = 19.2 " Web " Web = 3.65
" " Base = 3.61 " = 40.7 " Base " Base = 2.58
" Total = 8.87 " = 100 " " Total Periphery to Total Area = 2.42

Moment of Inertia = 32.3
Section Modulus, Head = 11.45
" " Base = 13.21

AMERICAN SOCIETY OF CIVIL ENGINEERS.

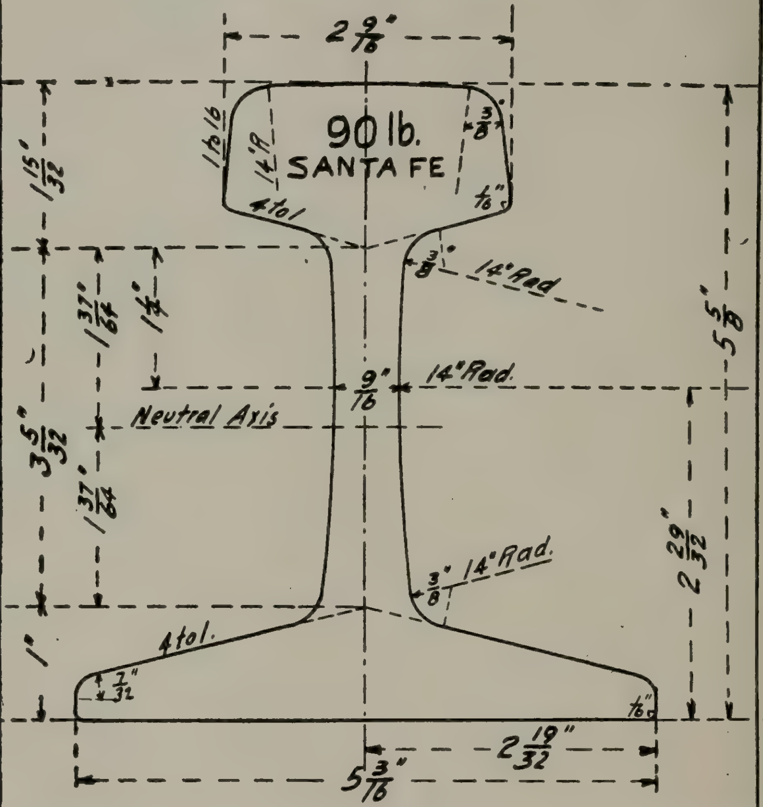
Standard A.S.C.E. Rail Section.



Area of Head = 3.68 sq in = 42 % Ratio Periphery of Head to Area of Head = 1.73
" " Web = 1.85 " = 21 " " " Web " Web = 3.51
" " Base = 3.30 " = .37 " " " Base " Base = 3.10
" " Total = 8.83 " = 100 " " Total Periphery to Total Area = 2.83

Moment of Inertia = 30.46
Section Modulus, Head = 10.59
" " Base = 12.18

The A.T. & S.F. Ry. System.

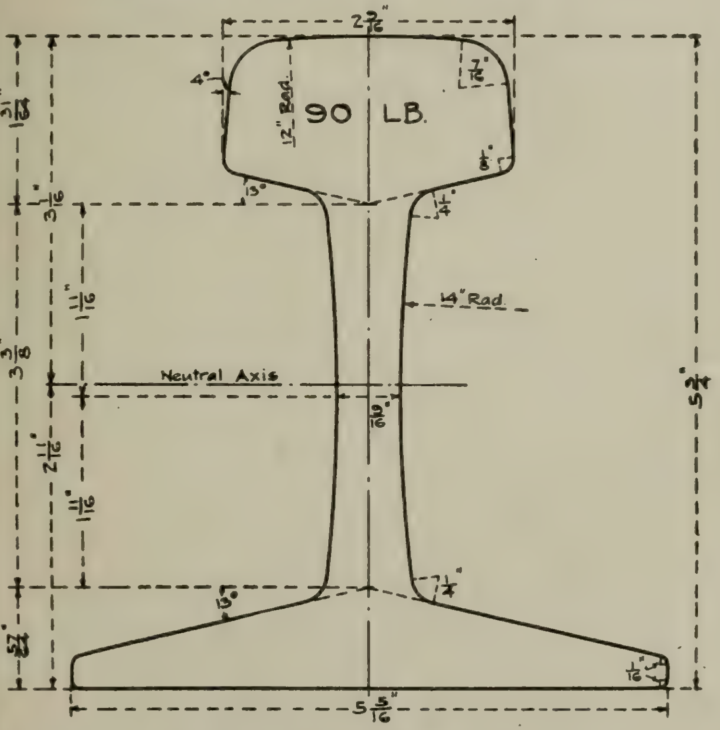


Area of head 3.16 sq. in. = 36.11 % Ratio Periphery of head to area of head 1.80
" web 2.10 " " = 24.00 " " " web " 3.60
" base 3.49 " " = 39.89 " " " base " 2.80
" Total 8.75 " " = 100.00 " " Total Periphery to Total area 2.60

Moment of Inertia = 37.60
Section Modulus, Head = 12.37
" " Base = 14.57

50021.

N. Y. N. H. & H. R. R.
STANDARD RAIL SECTION RE-ROLLED FROM 100LB. RAIL.

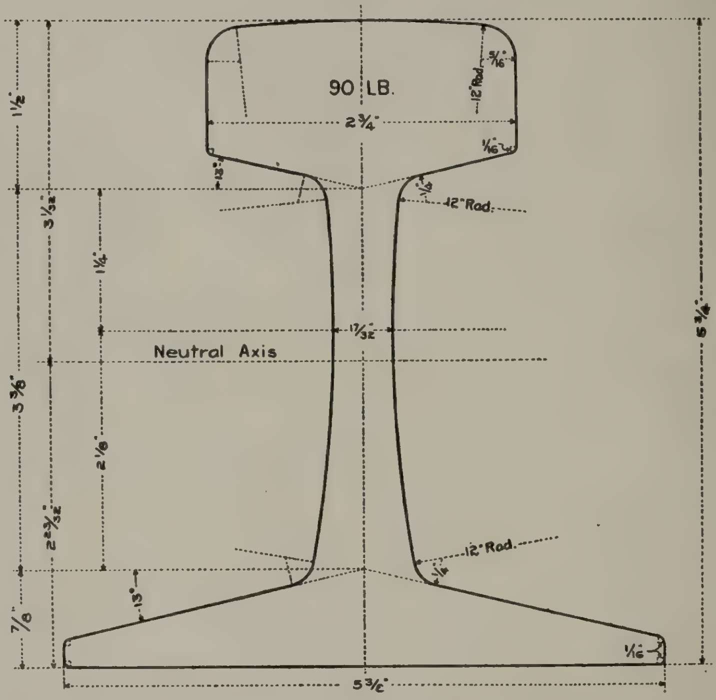


Area of Head	3.22 sq.in.	38 %	Ratio Periphery of Head to Area of Head	2.17
" " Web	2.22 "	26 "	" " Web " " Web	4.48
" " Base	3.10 "	36 "	" " Base " " Base	3.60
" " Total	8.54 "	100 "	" Total Periphery to Total Area	2.75

Moment of Inertia	38.81
Section Modulus, Head	12.67
" " Base	14.44

UNION PACIFIC SYSTEM, SOUTHERN PACIFIC CO.

Common Standard 90 lb. Rail Section.



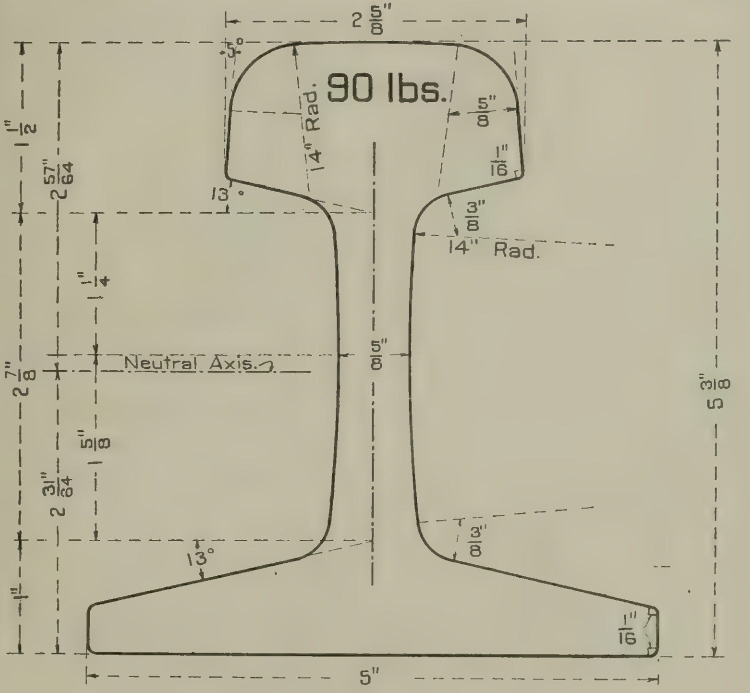
Area of Head = 3.55 sq. in. = 40.34%
" " Web = 2.23 " " = 25.34 "
" " Base = 3.02 " " = 34.32 "
" " Total = 8.80 " " = 100.00 "

Ratio Periphery of Head to Area of Head = 1.93
" " " Web " " " Web = 3.23
" " " Base " " " Base = 3.40
" Total Periphery " Total Area. = 2.18

Moment of Inertia = 41.90
Section Modulus, Head = 13.83
" " Base = 15.40

GREAT NORTHERN RAILWAY.

Standard G.N.Ry. Rail Section.

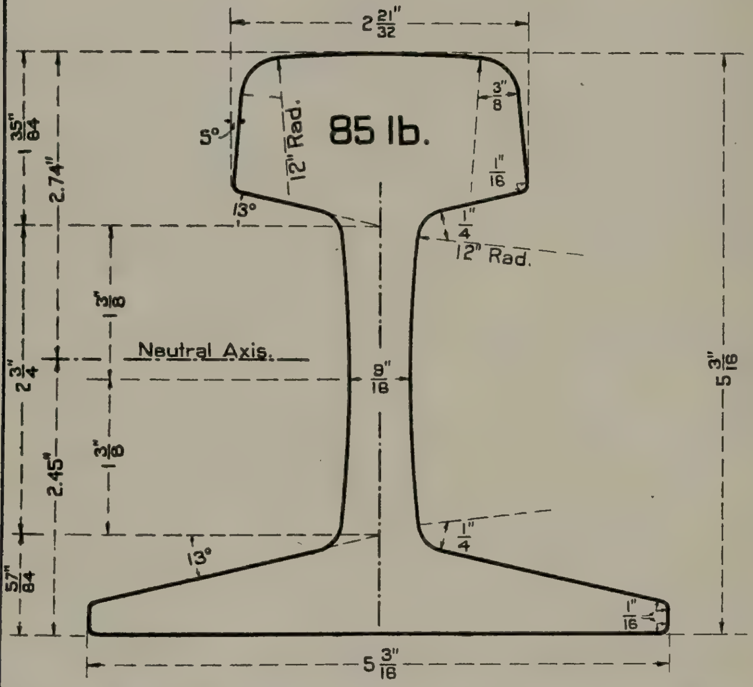


Area of Head = 3.25 sq.in. = 36.27 % Ratio Periphery of Head to Area of Head = 1.75
" " Web = 2.11 " = 23.55 " " " " Web " " " Web = 3.29
" " Base = 3.60 " = 40.18 " " " " Base " " " Base = 2.64
" " Total = 8.96 " = 100.00 " " Total Periphery to Total Area = 2.47

Moment of Inertia = 30.55
Section Modulus. Head = 10.57
" " Base = 12.30

CHICAGO, BURLINGTON & QUINCY RAILROAD.

Standard C.B.& Q.R.R. Rail Section.

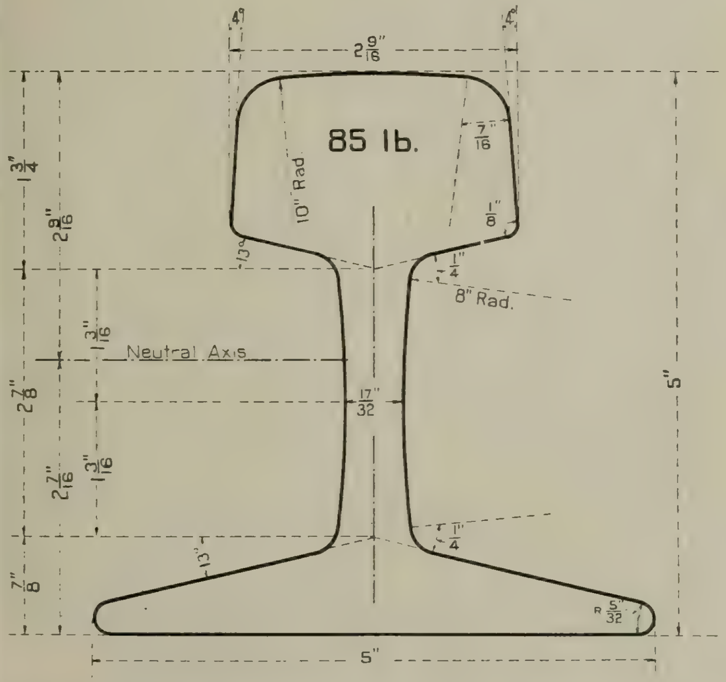


Area of Head - 3.49 sq. in.	= 42 %	Ratio Periphery of Head to Area of Head	- 1.774
" " Web - 1.74 "	= 21 "	" " Web " Web	- 3.677
" " Base - 3.07 "	= 37 "	" " Base " Base	- 3.257
" " Total - 8.30 "	= 100 "	" Total Periphery to Total Area	- 2.600

Moment of Inertia - 30.00
Section Modulus, Head - 10.93
" " Base - 12.23

PENNSYLVANIA RAILROAD.

Former Standard P.R.R. Rail Section.

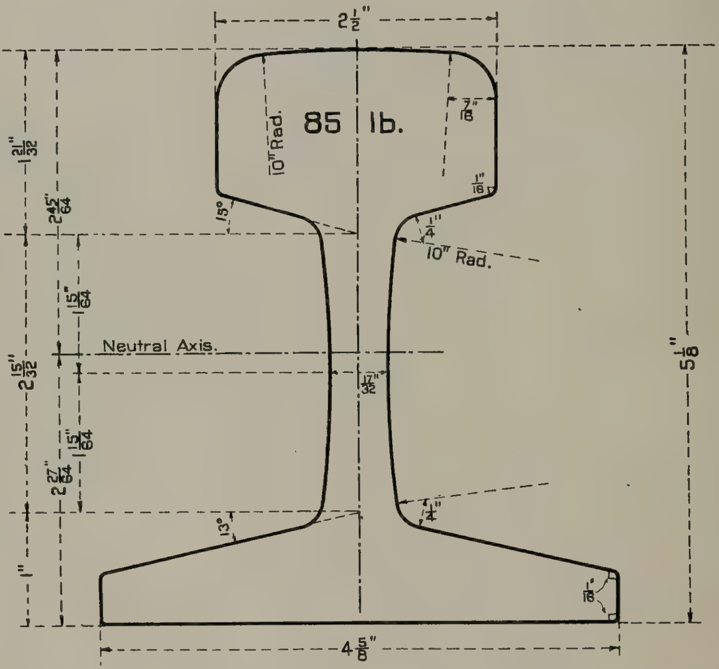


Area of Head=3.823	sq. in.= 46.1 %	Ratio Periphery of Head	to Area of Head	=1.63
" " Web=1.575	" = 19.0 "	" " " Web	" " Web	=3.59
" " Base=2.894	" = 34.9 "	" " " Base	" " Base	=3.25
" " Total=8.292	" =100.0 "	" Total Periphery	to Total Area	=2.57

Moment of Inertia = 27.428
Section Modulus, Head = 10.70
" " Base = 11.25

PENNSYLVANIA RAILROAD SYSTEM.

Standard P. S. Rail Section.

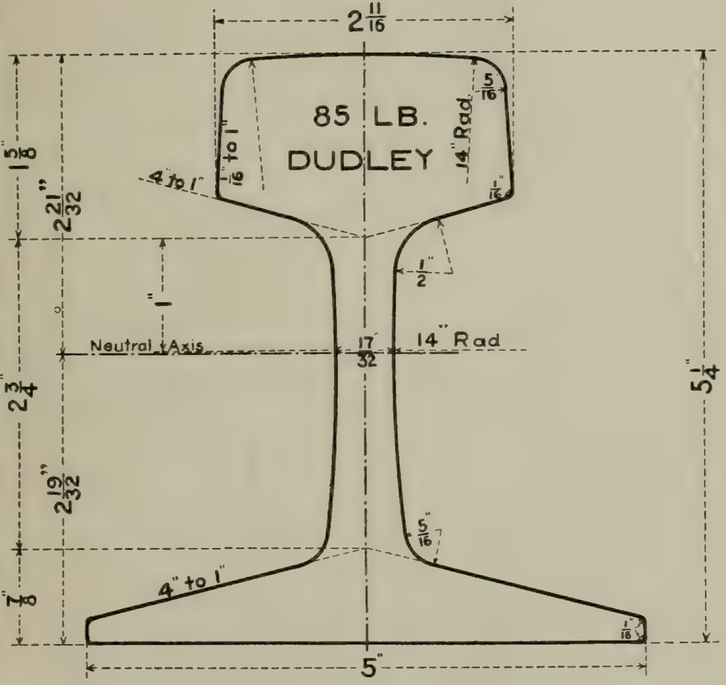


Area of Head = 3.57 sq.in. = 42.2%. Ratio Periphery of Head to Area of Head = 1.73
" " Web = 1.51 " = 17.8 " . " " " Web " " " Web = 3.81
" " Base = 3.39 " = 40.0 " " " " Base " " " Base = 2.69
" " Total = 8.47 " = 100.0 " " Total Periphery to Total Area. = 2.48

Moment of Inertia = 29.1
Section Modulus, Head = 10.77
" " Base = 12.02

C. R. R. Co. OF N. J.

85 LB. DUDLEY RAIL SECTION.

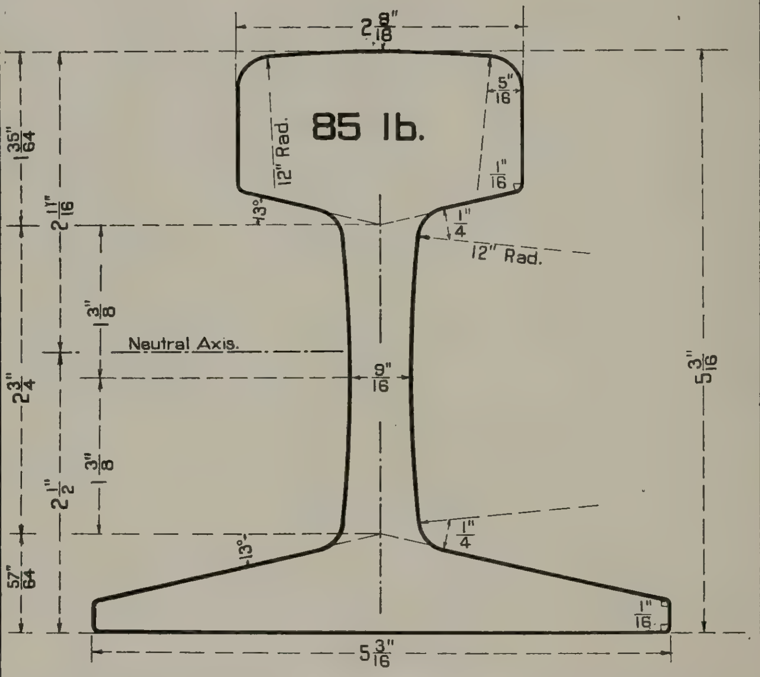


AREA OF HEAD = 3. 74 SQ. IN. = 45. 1 % RATIO PERIPHERY OF HEAD TO AREA OF HEAD = 2. 01
" " WEB = 1. 73 " " = 20. 9 " " " " WEB " " " WEB = 5. 35
" " BASE = 2. 82 " " = 34. 0 " " " " BASE " " " BASE = 3. 72
" " TOTAL = 8. 29 " " = 100. 0 " " TOTAL PERIPHERY TO TOTAL AREA = 2. 67

MOMENT OF INERTIA = 30. 4
SECTION MODULUS, HEAD = 11. 46
" " BASE = 11. 76

AMERICAN SOCIETY OF CIVIL ENGINEERS.

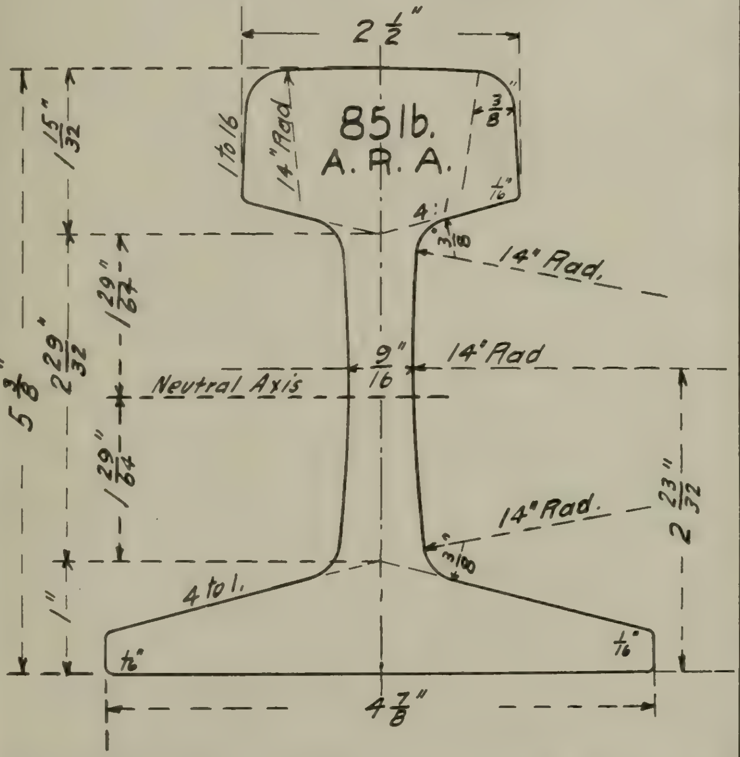
Standard A.S.C.E. Rail Section.



Area of Head = 3.50 sq. in. = 42 % Ratio Periphery of Head to Area of Head = 1.780
" " Web = 1.75 " = 21 " " " " Web " " " Web = 3.845
" " Base = 3.09 " = 37 " " " " Base " " " Base = 3.241
" " Total = 8.34 " = 100 " " Total Periphery to Total Area = 2.714

Moment of Inertia = 30.00
Section Modulus, Head = 11.16
" " Base = 12.00

The A.T. & S.F. Ry. System.



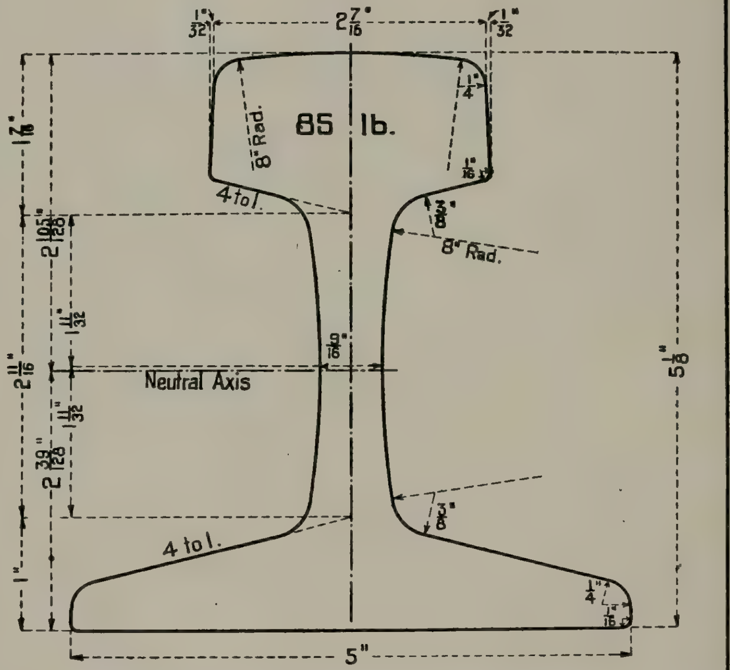
Area of head 3.09 sq. in = 37.01 % Ratio Periphery of head to area of head 1.80
" Web 1.90 " " = 22.75 " " " Web " 3.70
" base 3.36 " " = 40.24 " " " base " 2.80
" Total 8.35 " " = 100.00 " " Total Periphery to Total area 2.60

Moment of Inertia = 32.00
Section Modulus, Head = 10.96
" " Base = 13.06

50021

CANADIAN PACIFIC RY.

Standard C.P.R. Rail Section.

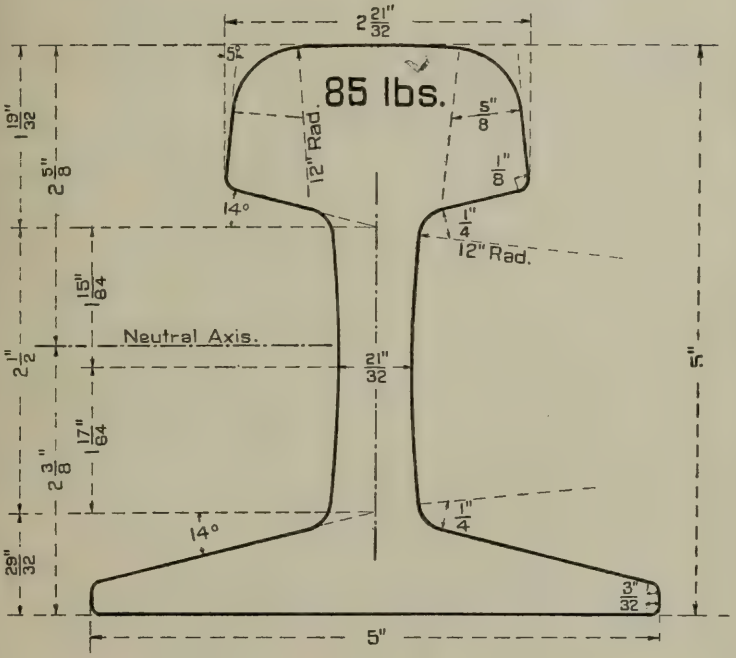


Area of Head = 3·068 sq.in. = 36·77 %. Ratio Periphery of Head to Area of Head = 1·965
" " Web = 1·853 " = 22·21 " . " " " Web " " " Web = 3·081
" " Base = 3·422 " = 41·02 " . " " " Base " " " Base = 2·875
" " Total = 8·343 " = 100·00 " . " Total Periphery to Total Area. = 2·586

Moment of Inertia = 29.492
Section Modulus, Head = 10·425
" " Base = 12.840

GREAT NORTHERN RAILWAY.

Standard G.N.Ry. Rail Section.

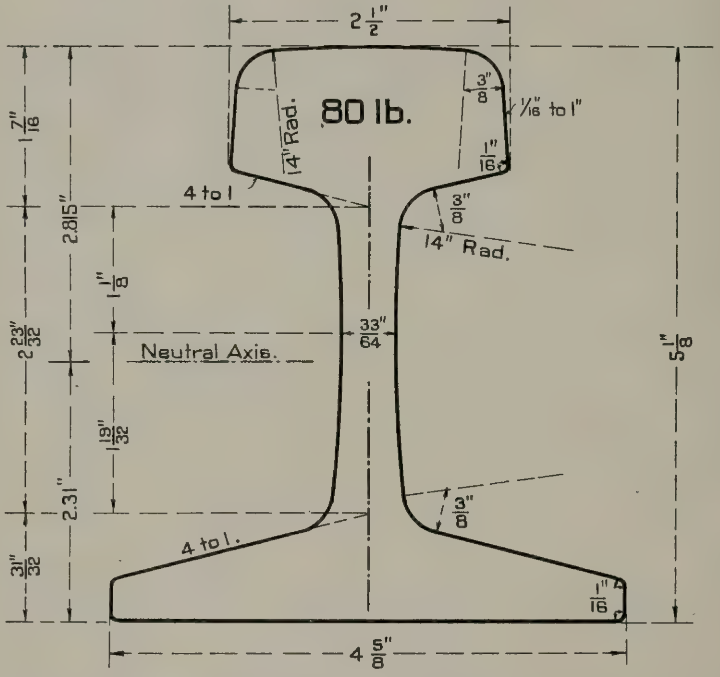


Area of Head = 3.47 sq.in = 41.7 % Ratio Periphery of Head to Area of Head = 1.74
" " Web = 1.86 " = 22.3 " " " " Web " " " Web = 3.19
" " Base = 3.00 " = 36.0 " " " " Base " " " Base = 3.13
" " Total = 8.33 " = 100.0 " " Total Periphery to Total Area = 2.57

Moment of Inertia = 26.65
Section Modulus. Head = 10.14
" " Base = 11.24

AMERICAN RAILWAY ASSOCIATION.

Standard A.R.A. Rail Section. Type A.

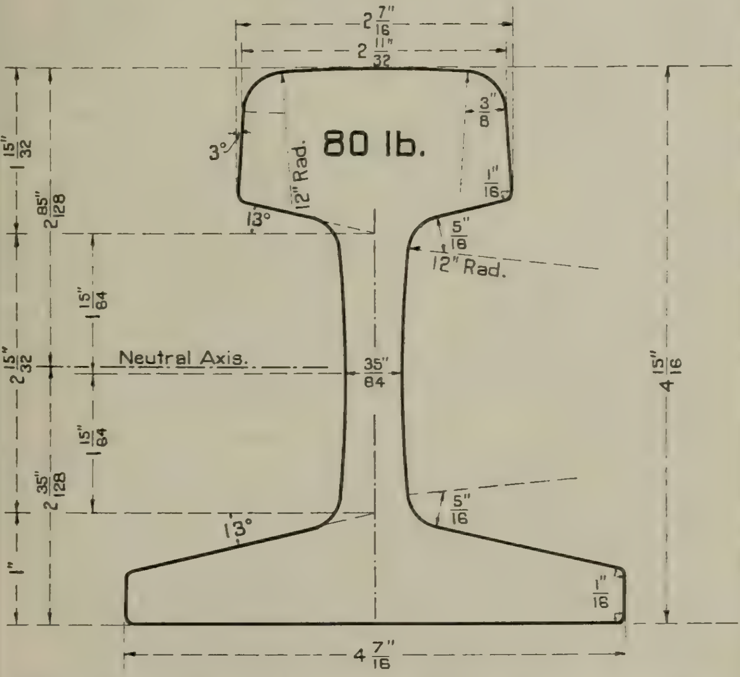


Area of Head 3.05 sq. in =	38.8 %	Ratio Periphery of Head to Area of Head	= 1.93
" " Web = 1.65 "	21.0 "	" " Web "	Web = 3.57
" " Base = 3.16 "	40.2 "	" " Base "	Base = 2.52
" " Total = 7.86 "	= 100 "	" Total Periphery to Total Area	= 2.50

Moment of Inertia = 28.8
Section Modulus, Head = 10.24
" " Base = 12.46

AMERICAN RAILWAY ASSOCIATION.

Standard A.R.A. Rail Section. Type B.

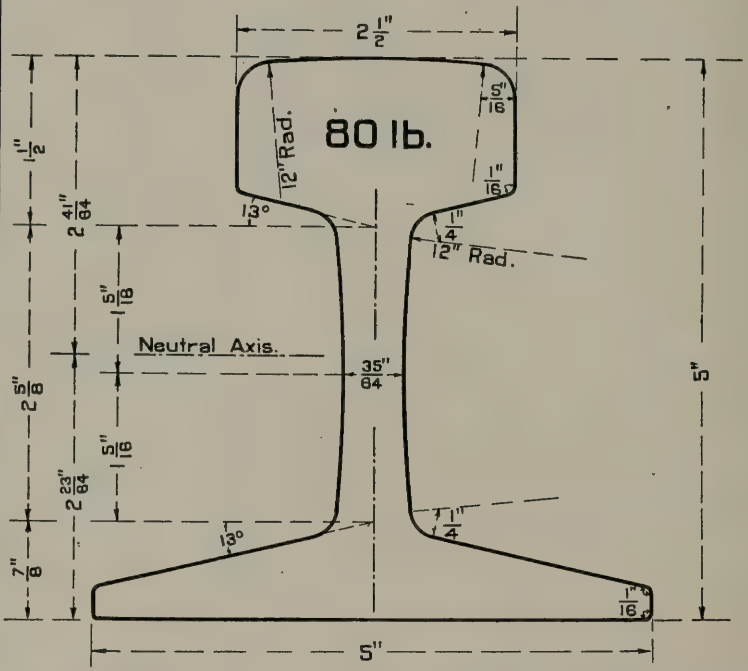


Area of Head = 3.07 sq in = 38.8 %	Ratio Periphery of Head to Area of Head = 1.79
" " Web = 1.54 " = 19.5 "	" " Web " Web = 3.57
" " Base = 3.30 " = 41.7 "	" " Base " Base = 2.72
" Total = 7.91 " = 100 "	Total Periphery to Total Area = 2.53

Moment of Inertia = 25.1
Section Modulus, Head = 9.38
" " Base = 11.08

AMERICAN SOCIETY OF CIVIL ENGINEERS.

Standard A.S.C.E. Rail Section.

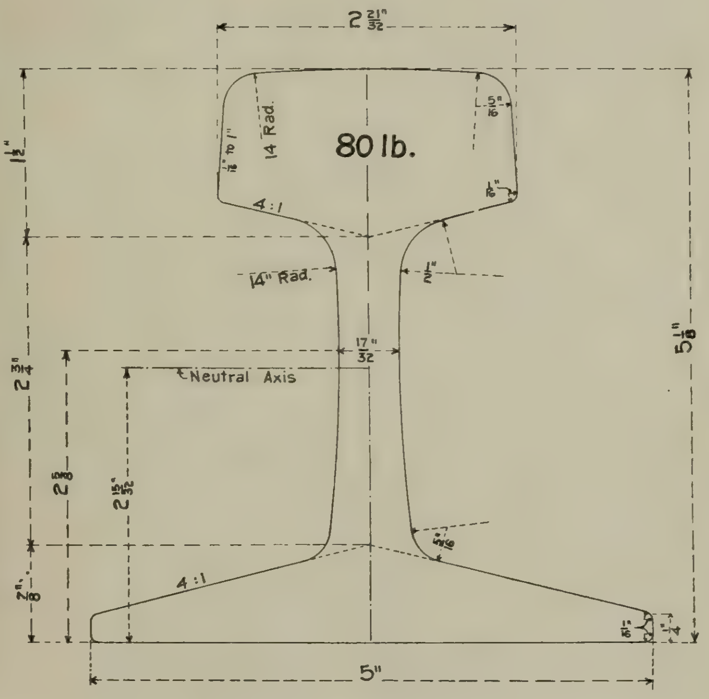


Area of Head = 3.31 sq. in. = 42 % Ratio Periphery of Head to Area of Head = 1.87
" " Web = 1.66 " = 21 " " " Web " Web = 3.73
" " Base = 2.92 " = 37 " " " Base " Base = 3.32
" " Total = 7.89 " = 100 " " Total Periphery to Total Area = 2.78

Moment of Inertia = 27.25
Section Modulus, Head = 10.30
" " Base = 11.97

NEW YORK CENTRAL LINES

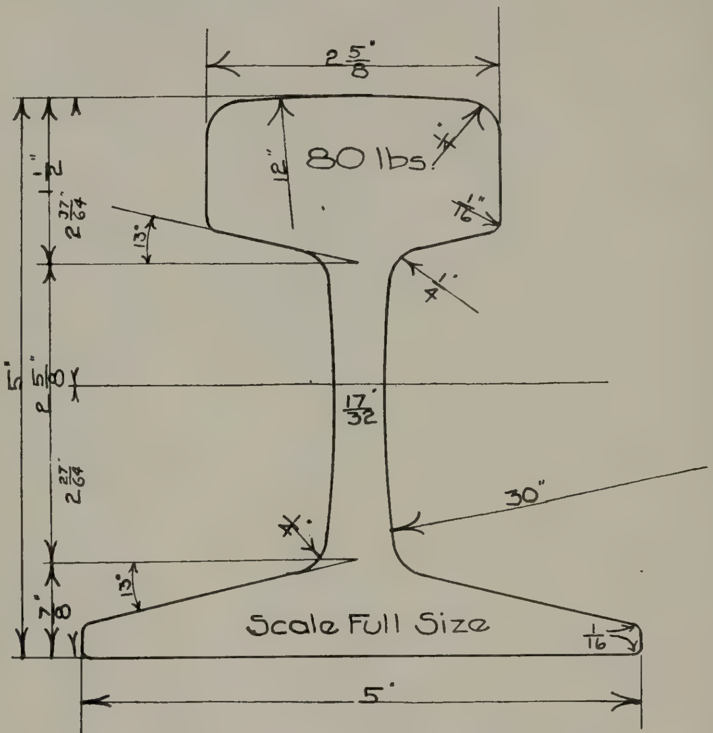
Dudley Rail Section



Area of Head = 3.44 sq.in = 43.1%. Ratio Periphery of Head to Area of Head = 2.05
" " Web = 1.64 " = 20.6 ". " " " Web " " " Web = 5.18
" " Base = 2.90 " = 36.3 ". " " " Base " " " Base = 3.59
" " Total = 7.98 " = 100.0 ". " Total Periphery to Total Area = 2.60

Moment of Inertia = 28.5
Section Modulus Head = 10.70
Base = 11.53

ERIE RAILROAD Co.
Standard ERIE (old) Rail Section

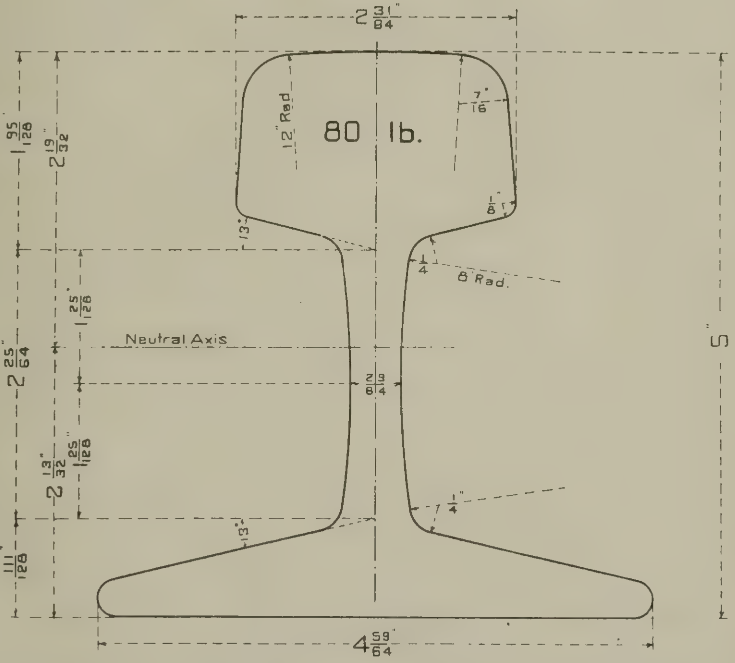


Area of Head = 3.46 = 43.9% Ratio Periphery of Head to Area of Head, 1.85
Web = 1.50 = 19.0% Web Web = 4.00
Base = 2.92 = 37.1% Base Base = 3.22
Total 7.88 = 100% Total Periphery to Total Area = 2.77

Moment of Inertia = 27.40
Section Modulus = Head = 10.58
Base = 11.37

HOCKING VALLEY RAILWAY

Standard **540** **CAMBRIA** Rail Section.



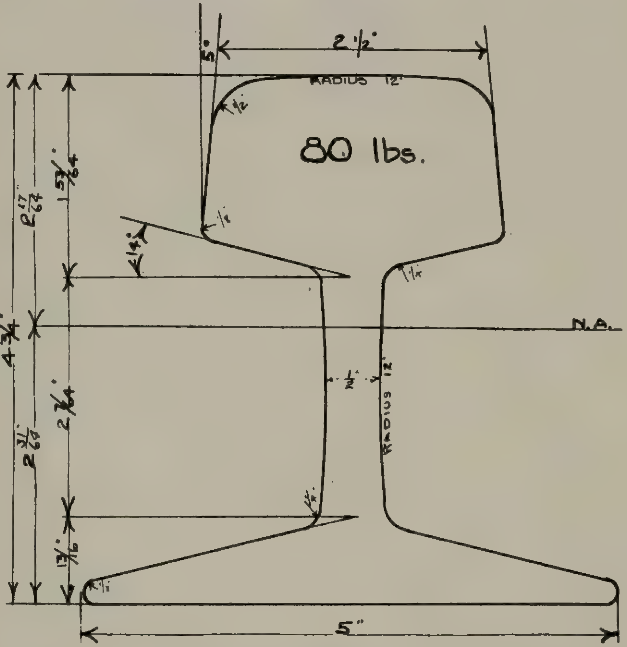
Area of Head = 3.71 sq.in. = 47.4
Web = 1.28 = 16.2
Base = 2.85 = 36.4
Total = 7.84 = 100.0

Ratio Periphery of Head to Area of Head = 1.70
Web Web = 4.49
Base Base = 3.29
Total Periphery to Total Area = 2.72

Moment of Inertia = 26.7
Section Modulus Head = 10.27
Base = 11.12

ERIE RAILROAD Co.

Standard S.C.R.R. Rail Section

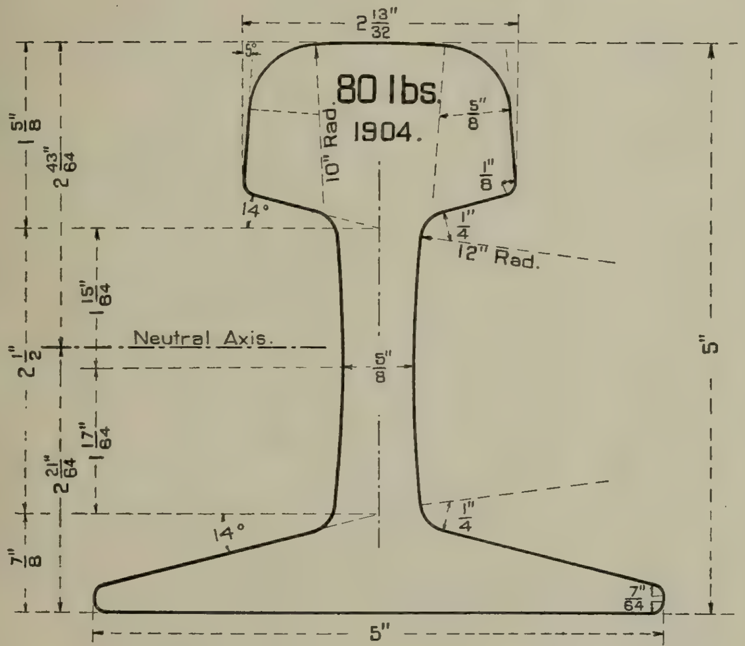


Area of head = 4.22 sq. in = 53.4% Ratio Periphery of head to Area of head = 1.66
web = 1.20 = 15.2% " " Web " Web = 4.01
Base = 2.48 = 31.4% " " Base " Base = 3.83
Total = 7.90 = 100.0% " Total Periphery to total Area = 2.70

Moment of Inertia = 22.33
Section Modulus, Head = 9.79
Base 9.04

GREAT NORTHERN RAILWAY.

Standard G.N.Ry. Rail Section.

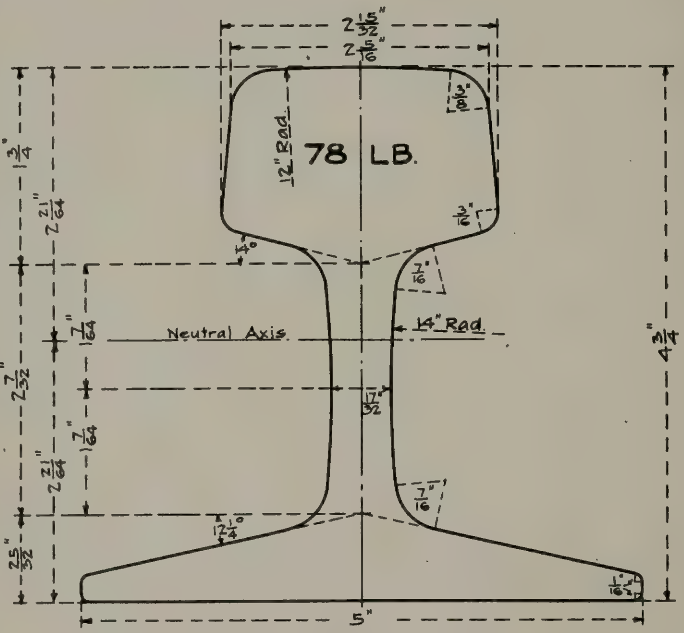


Area of Head = 3.23 sq.in. = 40.9 % Ratio Periphery of Head to Area of Head = 1.74
" " Web = 1.77 " = 22.5 " " " " Web " " Web = 3.37
" " Base = 2.89 " = 36.6 " " " " Base " " Base = 3.25
" " Total = 7.89 " = 100.0 " " Total Periphery to Total Area = 2.66

Moment of Inertia = 25.09
Section Modulus Head = 9.37
" " Base = 10.80

N. Y. N. H. & H. R. R.

STANDARD RAIL SECTION.

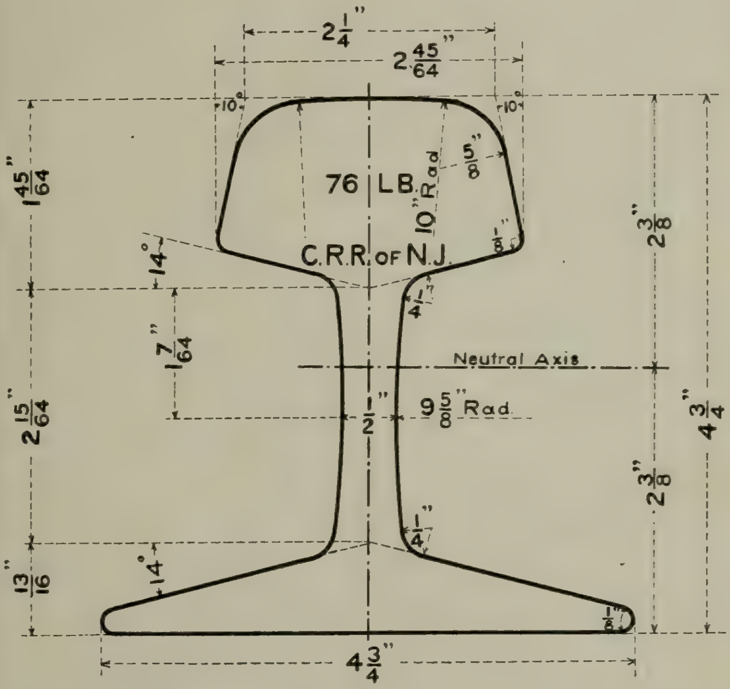


Area of Head = 3.71 sq.in. = 48%	Ratio Periphery of Head to Area of Head 1.96
" " Web = 1.38 " " = 18%	" " " Web " " " Web 6.04
" " Base = 2.59 " " = 34%	" " " Base " " " Base 4.02
" " Total = 7.68 " " = 100%	" Total Periphery to Total Area 2.71

Moment of Inertia	22.45
Section Modulus, Head	9.27
" " Base	9.64

C. R. R. Co. OF N. J

76 LB. C. R. R. OF N. J. RAIL SECTION.

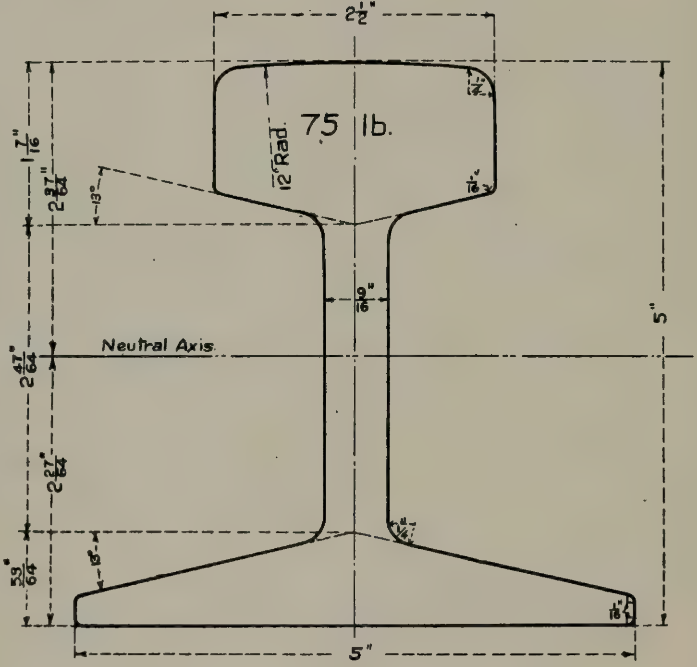


AREA OF HEAD = 3. 73 SQ. IN. = 50 0% RATIO PERIPHERY OF HEAD TO AREA OF HEAD = 1. 93
" " WEB = 1. 30 " " = 17. 4 " " " " WEB " " " WEB = 9. 33
" " BASE = 2. 43 " " = 32. 6 " " " " BASE " " " BASE = 4. 01
" " TOTAL = 7. 46 " " = 100. 0 " " TOTAL PERIPHERY TO TOTAL AREA = 2. 75

MOMENT OF INERTIA = 21.4
SECTION MODULUS, HEAD = 9.04
" " BASE = 9.00

BOSTON & MAINE RAILROAD SYSTEM

Standard 75 lb. Rail Section.

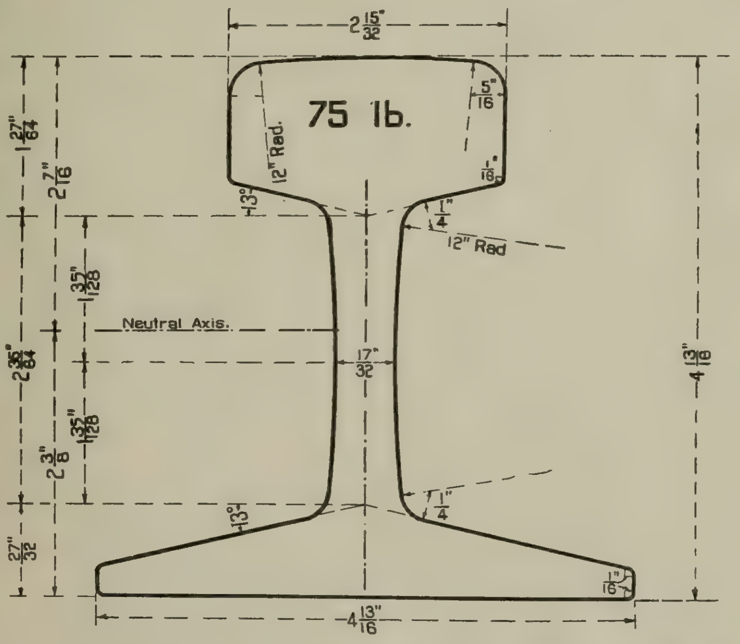


Area of Head = 3.156 sq in = 42.4% Ratio Periphery of Head to Area of Head = 2.07
" " Web = 1.605 " = 21.5 " " " " Web " " " Web = 3.52
" " Base = 2.693 " = 36.1 " " " " Base " " " Base = 3.71
" " Total = 7.454 " = 100.0 " " Total Periphery to Total Area = 2.9

Moment of Inertia = 25.17
Section Modulus Head = 9.75
" " Base = 10.40

AMERICAN SOCIETY OF CIVIL ENGINEERS.

Standard **A.S.C.E.** Rail Section.

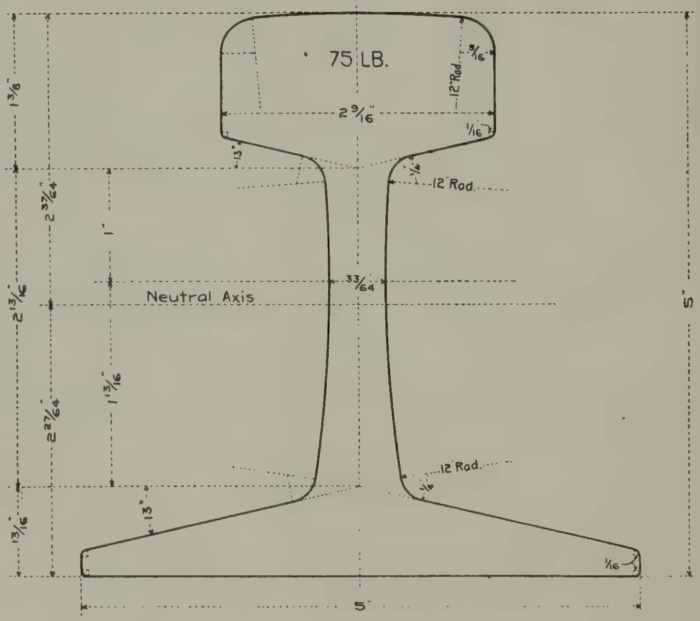


Area of Head	= 3.11	sq. in. = 42 %	Ratio Periphery of Head to Area of Head		= 1.86
" " Web	= 1.55	" = 21 "	" " " Web " " " Web		= 3.87
" " Base	= 2.74	" = 37 "	" " " Base " " " Base		= 3.34
" " Total	= 7.40	" = 100 "	" Total Periphery to Total Area		= 2.83

Moment of Inertia = 22.848
Section Modulus Head = 9.37
" " Base = 9.62

UNION PACIFIC SYSTEM, SOUTHERN PACIFIC CO.

Common Standard 75 lb. Rail Section.



Area of Head = 3.05 sq in = 41.4 %
" " Web = 1.74 " " = 23.6 "
" " Base = 2.57 " " = 35.0 "
" " Total = 7.36 " " = 100.0 "

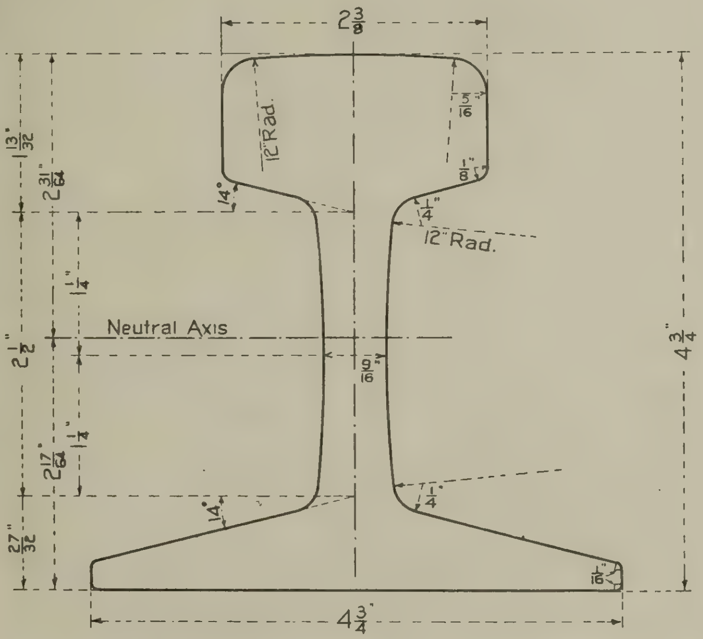
Ratio Periphery of Head to Area of Head = 2.01
" " Web " " Web = 3.34
" " Base " " Base = 3.77
" Total Periphery " Total Area = 2.94

Moment of Inertia = 28.50
Section Modulus, Head = 11.05
" " Base = 11.78

W H D 3,3,'10

NORTHERN PACIFIC RAILWAY.

Standard 72 Lb. Rail Section.

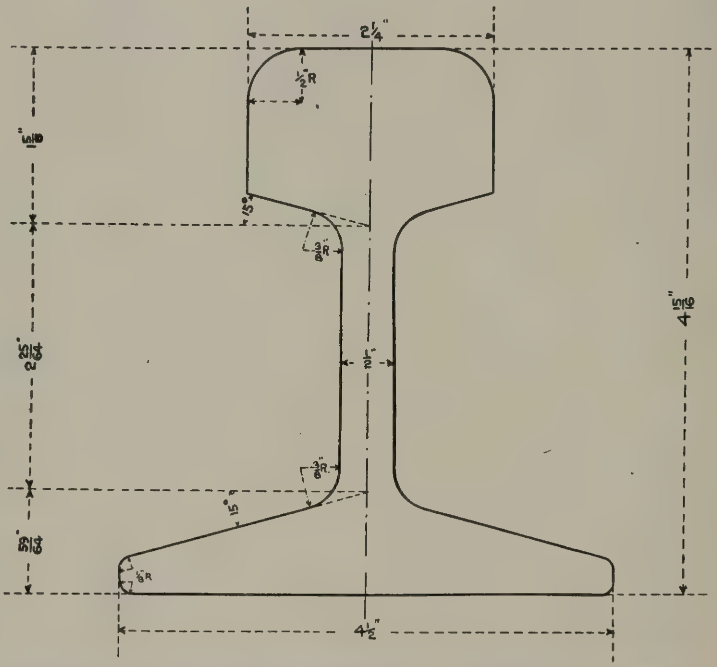


Area of Head	= 2.94 sq in.	= 41.5 %.	Ratio Periphery of Head to Area of Head	= 1.89
" " Web	= 1.56 "	= 22.0 ".	" " " Web " " " Web	= 3.78
" " Base	= 2.60 "	= 36.5 ".	" " " Base " " " Base	= 3.45
" " Total	= 7.10 "	= 100.0 ".	" Total Periphery to Total Area	= 2.88

Moment of Inertia = 21.69
Section Modulus. Head = 8.68
" " Base = 9.64

CANADIAN PACIFIC RAILWAY

Standard 72 lb. Rail Section.



Area of Head = 3·20 sq.in = 43·9%
" " Web = 1·33 " = 18·2%
" " Base = 2·76 " = 37·9%
" " Total = 7·29 " = 100%

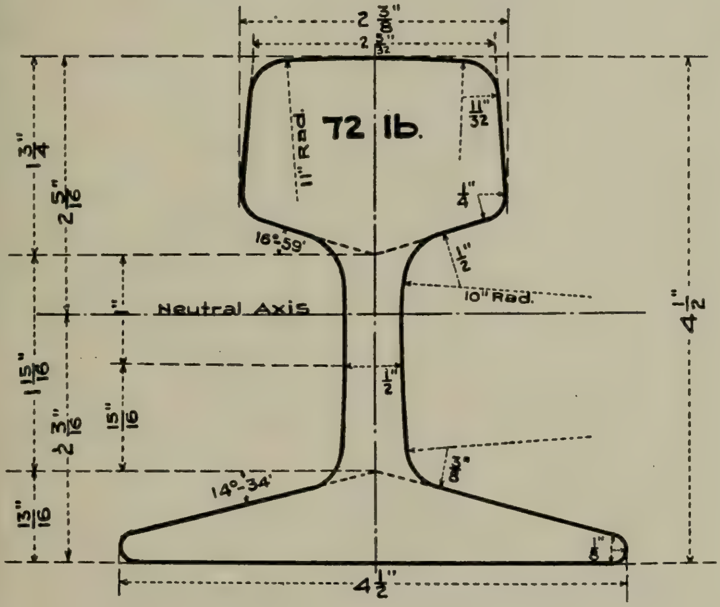
Ratio Periphery of Head to Area of Head =
" " " Web " " " Web =
" " " Base " " " Base =
" Total Periphery to Total Area.

Moment of Inertia 23·5
Section Modulus, Head = 9·07.
" " Base = 10·02.

BOSTON & ALBANY R.R.

N.Y.C. & H.R.R.R. Co. LESSEE.

STANDARD 72 LB. RAIL SECTION

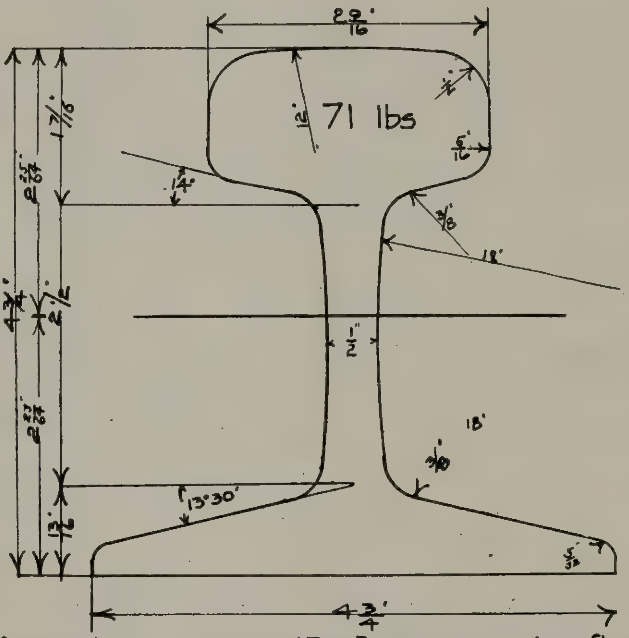


Area of Head = 3.50 sq.in. = 50.1 %. Ratio Periphery of Head to Area of Head = 2.02
" " Web = 1.15 " = 16.5 " " " " Web " " " Web = 6.61
" " Base = 2.33 " = 33.4 " " " " Base " " " Base = 4.05
" " Total = 6.98 " = 100.0 " " Total Periphery to Total Area. = 2.75

Moment of Inertia = 17.18
Section Modulus, Head = 7.43
" " Base = 7.84

ERIE RAILROAD Co.

Standard N.Y.S. & W.R.R. Rail Section



Area of head	= 3.07 sq in.	= 43.8%	Ratio Periphery of head to Area of head	=	1.86
Web	= 1.40	= 19.9%	Web	Web.	4.17
Base	= 2.54	= 36.3%	Base	Base =	3.49
Total	= 7.01	= 100.0%	Total Periphery to total Area	=	2.91

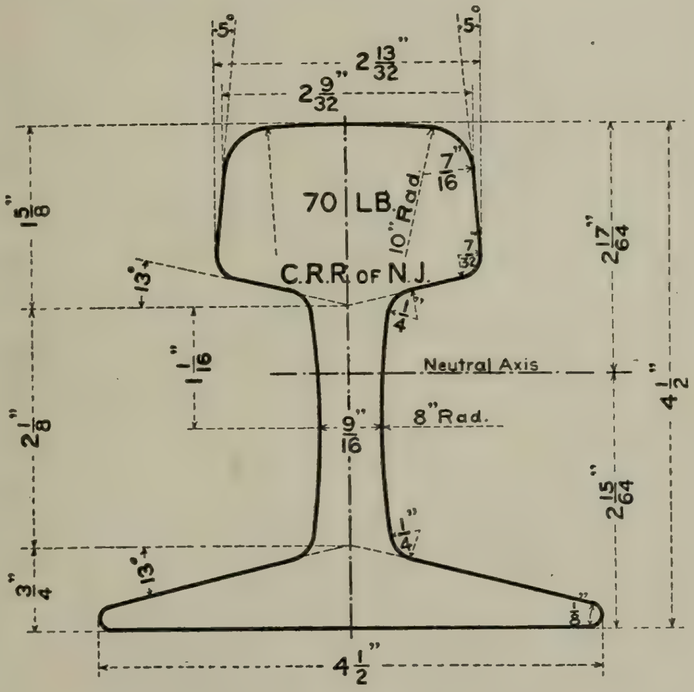
Moment of Inertia = 21.00

Section Modulus. Head = 8.75

Base = 8.94

C. R. R. Co. OF N. J.

70 LB. C. R. R. OF N. J RAIL SECTION.

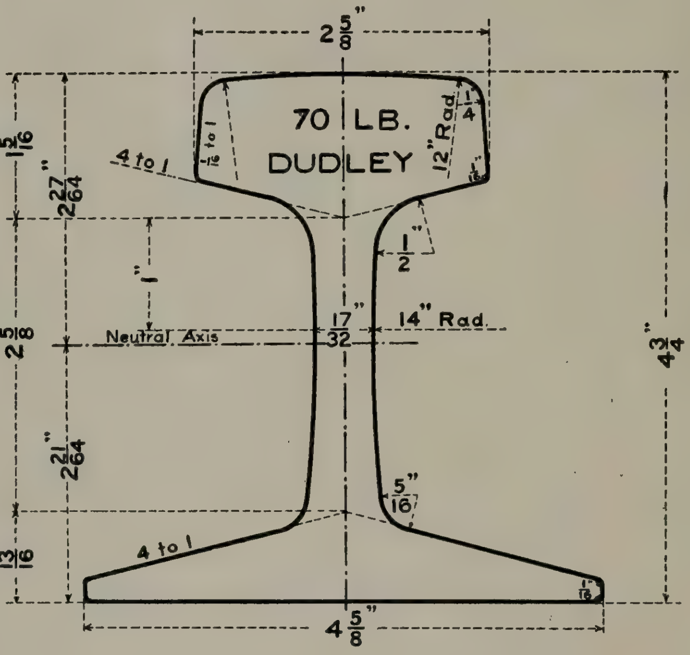


AREA OF HEAD = 3. 33 SQ. IN. = 48 1%. RATIO PERIFHERY OF HEAD TO AREA OF HEAD = 2 05
″ ″ WEB = 1. 40 ″ ″ = 20. 2 ″ ″ ″ ″ WEB ″ ″ ″ WEB = 5 18
″ ″ BASE = 2. 20 ″ ″ = 31. 7 ″ ″ ″ ″ BASE ″ ″ ″ BASE = 4 26
″ ″ TOTAL = 6. 93 ″ ″ = 100. 0 ″ ″ TOTAL PERIPHERY TO TOTAL AREA = 2. 49

MOMENT OF INERTIA = 17.3
SECTION MODULUS HEAD 7.65
″ ″ BASE = 7.75

C. R. R. Co. OF N. J.

70 LB. DUDLEY RAIL SECTION.

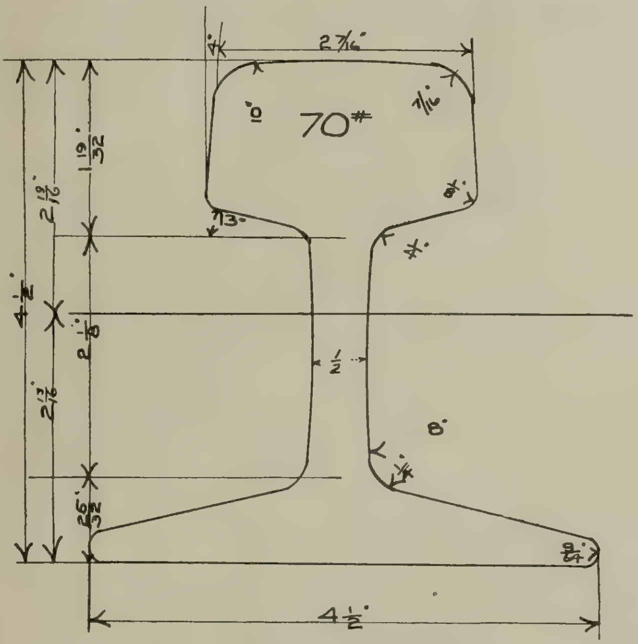


AREA OF HEAD = 2.87 SQ. IN. = 41.2% RATIO PERIPHERY OF HEAD TO AREA OF HEAD = 2.39
" " WEB = 1.66 " " = 23.8 " " " " WEB " " " WEB = 3.27
" " BASE = 2.43 " " = 35.0 " " " " BASE " " BASE = 4.01
" " TOTAL = 6.96 " " = 100.0 " " TOTAL PERIPHERY TO TOTAL AREA = 2.93

MOMENT OF INERTIA = 21.3
SECTION MODULUS, HEAD = 8.78
" BASE = 8.13

ERIE RAILROAD Co.

Standard N.Y.S.&W.R.R. Rail Section



Area of head = 3.34 sq.in. = 48.4% Ratio Periphery of head to Area of head = 1.76
web = 1.29 " = 18.7% " " Web " " Web = 3.88
Base = 2.27 " = 32.9% " " Base " " Base = 3.67
Total = 6.90 " = 100.0% " Total Periphery to total Area = 2.81

Moment of Inertia = 18.01
Section Modulus, Head = 7.88
" " Base = 8.13

Appendix C.

DROP TEST OF RAILS

DEFLECTION, ELONGATION AND COMPRESSION OF 85-LB. A. S. C. E. OPEN-HEARTH RAILS IN DROP TEST.

By C. S. Churchill, Chief Engineer, Norfolk & Western Railway.

This report gives statements and tables of drop tests and chemical analyses of open-hearth rails rolled for the Norfolk & Western Railway, giving results for heights of 15 ft., 18 ft. and 20 ft., and a comparison of the mill analysis with analysis of the borings from the rail. They were all 85-lb. rails of the A. S. C. E. section, except some 100-lb. A. R. A. section type B made at Gary.

The tests were arranged for by C. S. Churchill, and made by J. A. Colby, Inspector, at the various mills, through the aid of the manufacturers; and the chemical check analyses and reports thereon were made at the laboratory of the Norfolk & Western Railway by J. H. Gibboney, Chemist of the Norfolk & Western Railway. The tests were made on a few melts of a regular rolling. The drillings for analysis of rails were taken uniformly from two sets of positions, as noted on Fig. 1, position No. 1 being the four outer holes in cross-section of head, and position No. 2 being the inner hole, where maximum of segregated material is most often found. Drillings from the four outer holes were thoroughly mixed before analysis and are designated as No. 1 in the statement.

One piece for drop test was cut from extreme crop end of an "A" rail of each melt and subjected to test in a standard machine to a drop of 15 ft., and a very short section from this same piece was sent to Roanoke, Va., for analysis. In same manner two more pieces from other "A" rails of same melt were subjected to drop tests of 18 ft. and 20 ft.

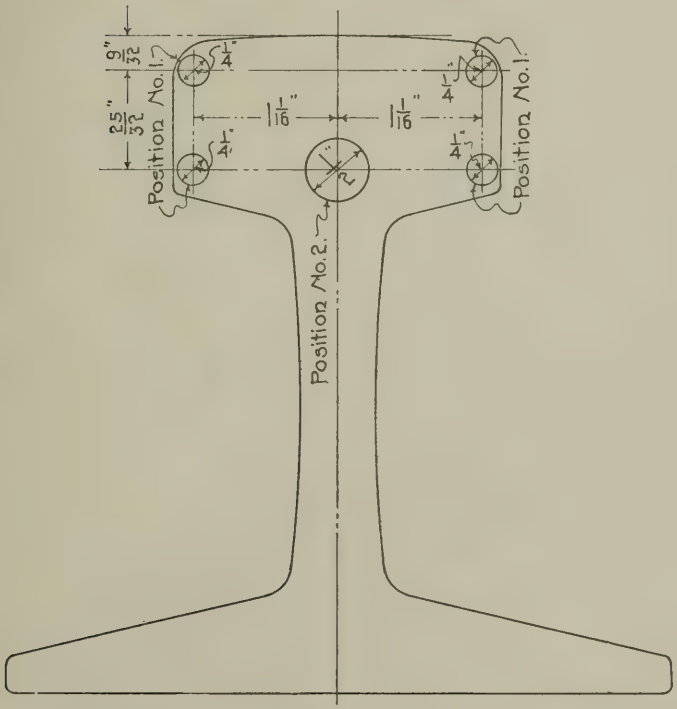
The tup was 2,000 lbs., the anvil 20,000 lbs., spring supported and supports 3 ft. apart. The sets, also elongation of base and contraction of head under these tests, were noted over six 1-in. spaces.

From the first "A" rail, as stated above, also from a lower rail from an ingot, taken at random from same melt, very short pieces were cut out for chemical analysis to furnish a comparison between the mill analysis and that of the rails, and the position of these chemical test pieces is noted in the statements.

Report No. 14, February, 1911.

The rails tested were as follows:

Carnegie Steel Co.	Tables 1 to 15, incl.
Pennsylvania Steel Co.	Tables 16 to 30, incl.
Tenn. Coal, Iron & R. R. Co.	Tables 31 to 42, incl.
Bethlehem Steel Co.	Tables 43 to 57, incl.
Maryland Steel Co.	Tables 58 to 64, incl.
Illinois Steel Co.—Gary Works	Tables 65 to 76, incl.



AMERICAN SOCIETY OF CIVIL ENGINEERS.. 85 LB. SECTION.
Showing position of test drillings.

FIG. 1.

CARNEGIE STEEL CO.

OPEN-HEARTH STEEL RAIL, 85-LB. A. S. C. E., ROLLED FOR THE NORFOLK & WESTERN RAILWAY, JULY, 1910, BY CARNEGIE STEEL COMPANY, EDGAR THOMSON RAIL MILL, BRADDOCK, PA.

Blooms rolled at the Homestead Plant.

Average total discard from blooms at Homestead, 15 per cent.

All blooms were chipped for surface defects before leaving Homestead.

Each bloom 9½ in. square as rolled at Homestead was hot stamped on top, in addition to which figures or letters were painted on same end to denote heat number and position in ingot to aid both the Homestead mill and the Edgar Thomson mill in keeping each melt separate when loading and unloading.

Blooms from any one heat were further shipped in separate cars and kept in separate piles after arrival at Edgar Thomson mill.

When rolling at Edgar Thomson was about to start, blooms were placed in the soaking pit with the stamped or top end up, and upon removal from soaking pit the top end was placed first on the roller table —all according to usual practice.

The average discard in rolling these blooms into rails at Edgar Thomson was about 6½ per cent. additional to the above 15 per cent., making a total of about 21½ per cent.

CARNEGIE—EDGAR THOMSON WORKS.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 1—Melt, 35218.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.60	.076	.038	.024	.63
A rail—1	.59	....	.030	.017	.65
2	.60	.084	.031	.021	.66
D rail—1	.62	....	.033	.027	.65
2	.63	.080	.030	.024	.65

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.50 in.	1.85 in.	2.10 in.
Permanent set, base	1.40 in.	1.70 in.	1.94 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.05 in.	1.05 in.	1.05 in.	1.05 in.	1.04 in.	6.27 in. equals .27 in.
18 ft.	1.04 in.	1.05 in.	1.07 in.	1.06 in.	1.06 in.	1.05 in.	6.33 in. equals .33 in.
20 ft.	1.05 in.	1.07 in.	1.08 in.	1.08 in.	1.07 in.	1.05 in.	6.40 in. equals .40 in.

Contraction on Head.

15 ft.	.95 in.	.93 in.	.96 in.	.92 in.	.96 in.	.97 in.	5.69 in. equals .31 in.
18 ft.	.96 in.	.94 in.	.93 in.	.92 in.	.94 in.	.96 in.	5.65 in. equals .35 in.
20 ft.	.95 in.	.93 in.	.92 in.	.92 in.	.93 in.	.97 in.	5.62 in. equals .38 in.

CARNEGIE—EDGAR THOMSON WORKS.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 2—Melt, 32244.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.63	.116	.024	.025	.70
A rail—1	.61	....	.033	.032	.70
2	.60	.110	.031	.030	.72
D rail—1	.63	....	.027	.026	.70
2	.64	.100	.030	.031	.70

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.45 in.	1.65 in.	1.75 in.
Permanent set, base	1.33 in.	1.53 in.	1.63 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.05 in.	1.06 in.	1.05 in.	1.04 in.	1.03 in.	6.27 in. equals .27 in.
18 ft.	1.04 in.	1.05 in.	1.06 in.	1.06 in.	1.05 in.	1.00 in.	6.26 in. equals .26 in.
20 ft.	1.04 in.	1.07 in.	1.06 in.	1.07 in.	1.06 in.	1.04 in.	6.34 in. equals .34 in.

Contraction on Head.

15 ft.	.96 in.	.95 in.	.95 in.	.95 in.	.95 in.	.97 in.	5.73 in. equals .27 in.
18 ft.	.97 in.	.94 in.	.94 in.	.93 in.	.94 in.	.95 in.	5.67 in. equals .33 in.
20 ft.	.96 in.	.95 in.	.94 in.	.93 in.	.94 in.	.97 in.	5.69 in. equals .31 in.

ANALYSIS.

Table 3—Melt, 43297.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.75	.110	.029	.030	.72
A rail—1	.63	....	.025	.029	.67
2	.63	.108	.025	.037	.69
D rail—1	.63	....	.020	.032	.72
2	.60	.110	.033	.029	.69

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.44 in.	1.47 in.	1.95 in.
Permanent set, base	1.34 in.	1.37 in.	1.84 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.05 in.	1.06 in.	1.06 in.	1.05 in.	1.04 in.	6.30 in. equals .30 in.
18 ft.	1.04 in.	1.05 in.	1.05 in.	1.06 in.	1.05 in.	1.03 in.	6.28 in. equals .28 in.
20 ft.	1.05 in.	1.07 in.	1.08 in.	1.06 in.	1.07 in.	1.04 in.	6.37 in. equals .37 in.

Contraction on Head.

15 ft.	.97 in.	.95 in.	.93 in.	.94 in.	.94 in.	.96 in.	5.69 in. equals .31 in.
18 ft.	.96 in.	.95 in.	.93 in.	.94 in.	.95 in.	.97 in.	5.70 in. equals .30 in.
20 ft.	.95 in.	.93 in.	.93 in.	.92 in.	.94 in.	.96 in.	5.63 in. equals .37 in.

ANALYSIS.

Table 4—Melt, 33363.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.62	.078	.033	.027	.62
A rail—1	.62	....	.033	.040	.72
2	.61	.088	.030	.041	.72
D rail—1	.58	....	.033	.035	.66
2	.58	.080	.037	.036	.70

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.47 in.	1.71 in.	1.86 in.
Permanent set, base	1.35 in.	1.61 in.	1.74 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.05 in.	1.06 in.	1.05 in.	1.05 in.	1.04 in.	6.29 in. equals .29 in.
18 ft.	1.05 in.	1.06 in.	1.06 in.	1.06 in.	1.06 in.	1.06 in.	6.35 in. equals .35 in.
20 ft.	1.05 in.	1.06 in.	1.07 in.	1.07 in.	1.07 in.	1.06 in.	6.38 in. equals .38 in.

Contraction on Head.

15 ft.	.98 in.	.95 in.	.95 in.	.93 in.	.95 in.	.96 in.	5.72 in. equals .28 in.
18 ft.	.96 in.	.93 in.	.94 in.	.95 in.	.93 in.	.96 in.	5.67 in. equals .32 in.
20 ft.	.97 in.	.95 in.	.92 in.	.94 in.	.91 in.	.96 in.	5.65 in. equals .35 in.

CARNEGIE—EDGAR THOMSON WORKS.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 5—Melt, 33219.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.69	.106	.040	.010	.71
A rail—1	.60	....	.039	.010	.75
2	.58	.108	.041	.010	.72
D rail—1	.58	....	.043	.016	.72
2	.58	.104	.045	.017	.75

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.50 in.	1.80 in.	1.82 in.
Permanent set, base	1.35 in.	1.73 in.	1.73 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.05 in.	1.06 in.	1.05 in.	1.04 in.	1.03 in.	6.28 in. equals .28 in.
18 ft.	1.04 in.	1.05 in.	1.06 in.	1.07 in.	1.06 in.	1.05 in.	6.33 in. equals .33 in.
20 ft.	1.03 in.	1.04 in.	1.06 in.	1.07 in.	1.07 in.	1.06 in.	6.33 in. equals .33 in.

Contraction on Head.

15 ft.	.96 in.	.92 in.	.95 in.	.91 in.	.95 in.	.97 in.	5.66 in. equals .34 in.
18 ft.	.97 in.	.94 in.	.93 in.	.95 in.	.93 in.	.93 in.	5.65 in. equals .35 in.
20 ft.	.96 in.	.95 in.	.93 in.	.93 in.	.93 in.	.90 in.	5.60 in. equals .40 in.

ANALYSIS.

Table 6—Melt, 34227.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.71	.124	.037	.013	.71
A rail—1	.72	....	.039	.027	.72
2	.68	.114	.043	.029	.75
D rail—1	.68	....	.039	.031	.75
2	.65	.118	.041	.031	.72

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.35 in.	1.57 in.	1.82 in.
Permanent set, base	1.24 in.	1.53 in.	1.70 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.06 in.	1.02 in.	1.07 in.	1.03 in.	1.05 in.	1.03 in.	6.26 in. equals .26 in.
18 ft.	1.03 in.	1.03 in.	1.06 in.	1.04 in.	1.07 in.	1.02 in.	6.25 in. equals .25 in.
20 ft.	1.06 in.	1.03 in.	1.08 in.	1.05 in.	1.06 in.	1.02 in.	6.30 in. equals .30 in.

Contraction on Head.

15 ft.	.97 in.	.95 in.	.95 in.	.93 in.	.97 in.	.95 in.	5.72 in. equals .28 in.
18 ft.	.98 in.	.96 in.	.94 in.	.93 in.	.92 in.	.95 in.	5.68 in. equals .32 in.
20 ft.	.98 in.	.96 in.	.93 in.	.94 in.	.93 in.	.94 in.	5.68 in. equals .32 in.

ANALYSIS.

Table 7—Melt, 44221.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.77	.096	.025	.017	.65
A rail—1	.64	....	.035	.014	.67
2	.64	.090	.045	.024	.69
D rail—1	.67	....	.029	.024	.65
2	.65	.088	.023	.024	.65

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.44 in.	1.65 in.	1.88 in.
Permanent set, base	1.31 in.	1.52 in.	1.70 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.05 in.	1.05 in.	1.06 in.	1.05 in.	1.04 in.	6.29 in. equals .29 in.
18 ft.	1.03 in.	1.04 in.	1.06 in.	1.06 in.	1.06 in.	1.05 in.	6.30 in. equals .30 in.
20 ft.	1.05 in.	1,06 in.	1.06 in.	1.07 in.	1.06 in.	1.05 in.	6.35 in. equals .35 in.

Contraction on Head.

15 ft.	.97 in.	.93 in.	.96 in.	.93 in.	.95 in.	.97 in.	5.71 in. equals .29 in.
18 ft.	.97 in.	.96 in.	.94 in.	.94 in.	.93 in.	.94 in.	5.68 in. equals .32 in.
20 ft.	.97 in.	.95 in.	.94 in.	.92 in.	.94 in.	.96 in.	5.68 in. equals .32 in.

CARNEGIE—EDGAR THOMSON WORKS.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 8—Melt, 33212.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.70	.090	.028	.019	.64
A rail—1.............	.67	....	.033	.012	.69
2.............	.67	.088	.032	.011	.68
D rail—1.............	.63	....	.035	.023	.69
2.............	.64	.088	.033	.026	.69

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.41 in.	1.55 in.	1.82 in.
Permanent set, base..................	1.32 in.	1.47 in.	1.71 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.05 in.	1.06 in.	1.04 in.	1.04 in.	6.27 in. equals .27 in.
18 ft.	1.04 in.	1.05 in.	1.06 in.	1.06 in.	1.05 in.	1.04 in.	6.30 in. equals .30 in.
20 ft.	1.04 in.	1.05 in.	1.06 in.	1.07 in.	1.06 in.	1.05 in.	6.33 in. equals .33 in.

Contraction on Head.

15 ft.	.97 in.	.95 in.	.95 in.	.94 in.	.94 in.	.96 in.	5.71 in. equals .29 in.
18 ft.	.96 in.	.94 in.	.95 in.	.92 in.	.95 in.	.97 in.	5.69 in. equals .31 in.
20 ft.	.97 in.	.95 in.	.92 in.	.92 in.	.94 in.	.96 in.	5.66 in. equals .34 in.

ANALYSIS.

Table 9—Melt, 45328.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.70	.094	.035	.024	.74
A rail—1.............	.64	....	.037	.026	.74
2.............	.65	.090	.033	.021	.71
D rail—1.............	.67	....	.022	.020	.75
2.............	.66	.096	.024	.017	.75

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.43 in.	1.60 in.	1.67 in.
Permanent set, base..................	1.30 in.	1.50 in.	1.55 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.04 in.	1.05 in.	1.06 in.	1.04 in.	1.04 in.	6.26 in. equals .26 in.
18 ft.	1.03 in.	1.04 in.	1.06 in.	1.06 in.	1.06 in.	1.03 in.	6.28 in. equals .28 in.
20 ft.	1.03 in.	1.05 in.	1.06 in.	1.07 in.	1.05 in.	1.04 in.	6.30 in. equals .30 in.

Contraction on Head.

15 ft.	....	.98 in.	.94 in.	.94 in.	.95 in.	.96 in.	......
18 ft.	.96 in.	.97 in.	.94 in.	.95 in.	.93 in.	.96 in.	5.71 in. equals .29 in.
20 ft.	.95 in.	.96 in.	.94 in.	.92 in.	.94 in.	.96 in.	5.67 in. equals .33 in.

ANALYSIS.

Table 10—Melt, 36223.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.53	.114	.036	.032	.73
A rail—1.............	.57	....	.037	.037	.75
2.............	.57	.100	.033	.037	.72
D rail—1.............	.50	....	.053	.037	.70
2.............	.52	.104	.051	.040	.75

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.45 in.	1.56 in.	1.75 in.
Permanent set, base..................	1.34 in.	1.47 in.	1.42 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.05 in.	1.05 in.	1.04 in.	1.04 in.	1.03 in.	6.25 in. equals .25 in.
18 ft.	1.03 in.	1.07 in.	1.05 in.	1.05 in.	1.05 in.	1.04 in.	6.29 in. equals .29 in.
20 ft.	1.03 in.	1.01 in.	1.03 in.	1.02 in.	1.04 in.	1.03 in.	6.16 in. equals .16 in.

Contraction on Head.

15 ft.	.95 in.	.95 in.	.96 in.	.94 in.	.96 in.	.97 in.	5.73 in. equals .27 in.
18 ft.	.96 in.	.96 in.	.93 in.	.94 in.	.93 in.	.95 in.	5.67 in. equals .33 in.
20 ft.	.99 in.	.98 in.	.97 in.	.98 in.	.96 in.	.97 in.	5.85 in. equals .15 in.

CARNEGIE—EDGAR THOMSON WORKS.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 11—Melt, 28251.

Position.	Manganese.	Silicon.	Sulphur.	Phos.	Carbon.	
Mill report	.70	.112	.036	.030	.66	....
A rail—1	.66	....	.033	.038	.77	....
2	.67	.096	.037	.036	.82	.826
D rail—1	.70	....	.035	.026	.78	....
2	.70	.108	.041	.030	.76	.784

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.25 in.	1.45 in.	1.61 in.
Permanent set, base	1.14 in.	1.32 in.	1.54 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.05 in.	1.05 in.	1.04 in.	1.04 in.	6.26 in. equals .26 in.
18 ft.	1.03 in.	1.05 in.	1.05 in.	1.06 in.	1.05 in.	1.05 in.	6.29 in. equals .29 in.
20 ft.	1.03 in.	1.05 in.	1.05 in.	1.07 in.	1.06 in.	1.04 in.	6.30 in. equals .30 in.

Contraction on Head.

15 ft.	.97 in.	.95 in.	.94 in.	.96 in.	.94 in.	.96 in.	5.72 in. equals .28 in.
18 ft.	.97 in.	.95 in.	.94 in.	.93 in.	.95 in.	.97 in.	5.71 in. equals .29 in.
20 ft.	.94 in.	.95 in.	.92 in.	.94 in.	.93 in.	.96 in.	5.64 in. equals .36 in.

ANALYSIS.

Table 12—Melt, 32341.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.73	.100	.034	.016	.62
A rail—1	.57	....	.041	.012	.65
2	.62	.108	.037	.015	.65
D rail—1	.63	....	.037	.010	.67
2	.64	.096	.037	.013	.65

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.51 in.	1.75 in.	2.01 in.
Permanent set, base	1.39 in.	1.65 in.	1.91 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.01 in.	1.05 in.	1.05 in.	1.07 in.	1.05 in.	1.04 in.	6.27 in. equals .27 in.
18 ft.	1.03 in.	1.06 in.	1.07 in.	1.04 in.	1.06 in.	1.05 in.	6.31 in. equals .31 in.
20 ft.	1.03 in.	1.07 in.	1.07 in.	1.07 in.	1.07 in.	1.06 in.	6.37 in. equals .37 in.

Contraction on Head.

15 ft.	.95 in.	.93 in.	.96 in.	.93 in.	.93 in.	.99 in.	5.69 in. equals .31 in.
18 ft.	.94 in.	.97 in.	.93 in.	.94 in.	.93 in.	.96 in.	5.67 in. equals .33 in.
20 ft.	.92 in.	.92 in.	.94 in.	.91 in.	.92 in.	.96 in.	5.57 in. equals .43 in.

ANALYSIS.

Table 13—Melt, 44345.

Position.	Manganese.	Silicon.	Sulphur.	Phos.	Carbon.	
Mill report	.77	.136	.046	.026	.75	....
A rail—1	.72	....	.031	.021	.80	....
2	.77	.124	.061	.044	1.02	1.024
D rail—1	.70	....	.049	.026	.73	....
2	.74	.130	.035	.029	.74	....

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.25 in.	1.57 in.	1.73 in.
Permanent set, base	1.19 in.	1.49 in.	1.69 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.02 in.	1.03 in.	1.04 in.	1.05 in.	1.05 in.	1.04 in.	6.23 in. equals .23 in.
18 ft.	1.03 in.	1.06 in.	1.04 in.	1.05 in.	1.04 in.	1.05 in.	6.27 in. equals .27 in.
20 ft.	1.04 in.	1.03 in.	1.06 in.	1.06 in.	1.06 in.	1.03 in.	6.28 in. equals .28 in.

Contraction on Head.

15 ft.	.97 in.	.96 in.	.93 in.	.97 in.	.95 in.	.94 in.	5.72 in. equals .28 in.
18 ft.	.94 in.	.96 in.	.93 in.	.94 in.	.94 in.	.98 in.	5.69 in. equals .31 in.
20 ft.	.98 in.	.97 in.	.92 in.	.96 in.	.92 in.	.93 in.	5.68 in. equals .32 in.

CARNEGIE—EDGAR THOMSON WORKS.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 14—Melt, 32241.

Position.	Manganese.	Silicon.	Sulphur.	Phos.	Carbon.	
Mill report	.66	.096	.040	.033	.66	....
A rail—1	.65	....	.047	.034	.73	....
2	.69	.104	.061	.035	.98	1.009
D rail—1	.62	....	.038	.025	.75	....
2	.63	.096	.043	.025	.77	....

DROP TEST.

	15 ft Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.20 in.	1.44 in.	1.62 in.
Permanent set, base	1.14 in.	1.37 in.	1.51 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.05 in.	1.06 in.	1.05 in.	1.04 in.	1.00 in.	6.24 in. equals .24 in.
18 ft.	1.06 in.	1.05 in.	1.06 in.	1.05 in.	1.05 in.	1.03 in.	6.30 in. equals .30 in.
20 ft.	1.02 in.	1.06 in.	1.07 in.	1.06 in.	1.07 in.	1.06 in.	6.34 in. equals .34 in.

Contraction on Head.

15 ft.	.96 in.	.95 in.	.95 in.	.96 in.	.98 in.	.98 in.	5.78 in. equals .22 in.
18 ft.	.97 in.	.96 in.	.93 in.	.96 in.	.91 in.	.97 in.	5.70 in. equals .30 in.
20 ft.	.95 in.	.95 in.	.95 in.	.94 in.	.95 in.	.94 in.	5.68 in. equals .32 in.

ANALYSIS.

Table 15—Melt, 39222.

Position.	Manganese.	Silicon.	Sulphur.	Phos.	Carbon.	
Mill report	.75	.130	.040	.033	.66	....
A rail—1	.82	....	.041	.020	.76	....
2	.82	.120	.045	.036	.77	.784
D rail—1	.72	....	.043	.025	.66	....
2	.75	.112	.039	.036	.72	....

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.37 in.	1.64 in.	1.71 in.
Permanent set, base	1.25 in.	1.54 in.	1.60 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.06 in.	1.06 in.	1.04 in.	1.04 in.	6.28 in. equals .28 in.
18 ft.	1.04 in.	1.06 in.	1.06 in.	1.06 in.	1.05 in.	1.05 in.	6.32 in. equals .32 in.
20 ft.	1.04 in.	1.05 in.	1.06 in.	1.07 in.	1.05 in.	1.05 in.	6.32 in. equals .32 in.

Contraction on Head.

15 ft.	.97 in.	.95 in.	.94 in.	.95 in.	.95 in.	.97 in.	5.73 in. equals .27 in.
18 ft.	.98 in.	.95 in.	.94 in.	.93 in.	.94 in.	.96 in.	5.70 in. equals .30 in.
20 ft.	.96 in.	.94 in.	.94 in.	.93 in.	.93 in.	.95 in.	5.65 in. equals .35 in.

NOTES ON CHEMICAL ANALYSIS OF CARNEGIE OPEN-HEARTH STEEL RAIL, JULY, 1910.

By

J. H. Gibboney, Chemist.

Standard drillings. All carbons in two decimals, our report, by color, three decimals by combustion. Only in cases where there was apparent wide variations between mill results and our findings were combustion carbons run.

Heat 39222—Carbons higher than mill report. Little segregation.

Heat 32241—Carbon segregation in top of ingot, as well as other variations.

Heat 44345—Carbon and other segregation in top of ingot.

Heat 32341—Very good agreement in ingot as well as with mill report.

Heat 28251—Carbons somewhat higher than mill report. No segregation.

Heat 36223—Very good agreement in ingot and with mill report.

Heat 45328—Very good agreement in ingot and with mill report.

Heat 33212—Very good agreement in ingot and with mill report.

Heat 44221—Very good agreement in ingot with only a variation noted in Manganese.

Heat 34227—Very good agreement in ingot and with mill report.

Heat 33219—Very good agreement in ingot and with mill report, except that our Manganese is slightly lower.

Heat 33363—Very good agreement in ingot. Our Carbons slightly higher in top of ingot.

Heat 43297—Very good agreement in ingot and with mill report, except that our Manganese is lower.

Heat 32244—Very good agreement in ingot and with mill report.

Heat 35218—Very good agreement in ingot and with mill report.

From the above it will be noted that only in three heats are there any variations of any real significance, that is, Heats 39222, 32241 and 44345. In Heat 39222 we get a higher carbon, certainly not higher than should be expected to give satisfactory service, however higher than the mill report. No segregation noted in ingot. In Heat 32241 we find the top of ingot segregated, with the "D" rail very close to the mill report, as well as our findings. The same holds true in the case of Heat 44345. We might also add that in Heat 28251 we find the Carbons higher than the mill report; however, this heat is sound steel, no segregation, and the Carbons are not high enough to cause us to believe that this steel would prove unsatisfactory in service.

PENNSYLVANIA STEEL CO.

Open-Hearth Steel Rail—85-lb. A. S. C. E. Section, Rolled for the Norfolk & Western Railway, July, 1910—Pennsylvania Steel Company, Steelton, Pa.

The average discard from blooms ranged from 15 to 20 per cent.

PENNSYLVANIA STEEL COMPANY—STEELTON MILL.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 16—Melt, 25714.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.60	.070	.051	.010	.75
A rail—1	.60	....	.050	.014	.75
2	.62	.102	.109	.019	1.020
C rail—1	.57	....	.086	.016	.65
2	.57	.084	.088	.019	.655

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.38 in.	1.50 in.	1.70 in.
Permanent set, base	1.28 in.	1.42 in.	1.56 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.06 in.	1.03 in.	1.04 in.	1.04 in.	1.04 in.	6.25 in. equals .25 in.
18 ft.	1.06 in.	1.06 in.	1.06 in.	1.06 in.	1.03 in.	1.04 in.	6.31 in. equals .31 in.
20 ft.	1.06 in.	1.06 in.	1.04 in.	1.06 in.	1.04 in.	1.06 in.	6.32 in. equals .32 in.

Contraction on Head.

15 ft.	.96 in.	.98 in.	.94 in.	.96 in.	.94 in.	.96 in.	5.74 in. equals .26 in.
18 ft.	.96 in.	.96 in.	.94 in.	.94 in.	.94 in.	.98 in.	5.72 in. equals .28 in.
20 ft.	.96 in.	.94 in.	.94 in.	.93 in.	.94 in.	.98 in.	5.69 in. equals .31 in.

ANALYSIS.

Table 17—Melt, 23737.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.73	.100	.056	.015	.71
A rail—1	.70	....	.078	.017	.70
2	.71	.066	.084	.021	.714
C rail—1	.69	....	.074	.019	.70
2	.70	.066	.070	.020	.702

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.32 in.	1.46 in.	1.74 in.
Permanent set, base	1.26 in.	1.37 in.	1.60 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.05 in.	1.05 in.	1.04 in.	1.05 in.	1.04 in.	6.26 in. equals .26 in.
18 ft.	1.06 in.	1.07 in.	1.05 in.	1.05 in.	1.04 in.	1.05 in.	6.32 in. equals .32 in.
20 ft.	1.04 in.	1.06 in.	1.06 in.	1.04 in.	1.06 in.	1.04 in.	6.30 in. equals .30 in.

Contraction on Head.

15 ft.	.99 in.	.94 in.	.94 in.	.93 in.	.96 in.	.97 in.	5.73 in. equals .27 in.
18 ft.	.97 in.	.95 in.	.96 in.	.95 in.	.95 in.	.99 in.	5.77 in. equals .23 in.
20 ft.	.98 in.	.98 in.	......	......	.91 in.	.95 in.	5.67 in. equals .33 in.

ANALYSIS.

Table 18—Melt, 24723.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.61	.080	.049	.012	.75
A rail—1	.60	....	.048	.016	.75
2	.60	.084	.064	.017	.767
C rail—1	.64	....	.058	.016	.63
2	.64	.084	.056	.020	.625

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.16 in.	1.62 in.	1.44 in.
Permanent set, base	1.11 in.	1.52 in.	1.36 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.04 in.	1.04 in.	1.03 in.	1.04 in.	6.23 in. equals .23 in.
18 ft.	1.04 in.	1.06 in.	1.05 in.	1.06 in.	1.05 in.	1.04 in.	6.30 in. equals .30 in.
20 ft.	1.04 in.	1.06 in.	1.04 in.	1.06 in.	1.04 in.	1.06 in.	6.30 in. equals .30 in.

Contraction on Head.

15 ft.	.98 in.	.95 in.	.95 in.	.94 in.	.97 in.	.98 in.	5.77 in. equals .23 in.
18 ft.	.98 in.	......	......	......	.94 in.	.96 in.	5.70 in. equals .30 in.
20 ft.	.98 in.	.94 in.	.92 in.	.98 in.	.94 in.	.98 in.	5.74 in. equals .26 in.

PENNSYLVANIA STEEL COMPANY—STEELTON MILL.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 19—Melt, 24726.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.62	.060	.077	.018	.67
A rail—1	.62	....	.080	.010	.73
2	.64	.056	.132	.024	.849
C rail—1	.67	....	.084	.019	.75
2	.64	.075	.088	.020	.773

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.48 in.	1.70 in.	1.94 in.
Permanent set, base	1.36 in.	1.60 in.	1.56 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.04 in.	1.04 in.	1.04 in.	1.05 in.	6.25 in. equals .25 in.
18 ft.	1.06 in.	1.08 in.	1.06 in.	1.06 in.	1.03 in.	1.04 in.	6.33 in. equals .33 in.
20 ft.	1.06 in.	1.06 in.	1.10 in.	1.02 in.	1.04 in.	1.06 in.	6.34 in. equals .34 in.

Contraction on Head.

15 ft.	.98 in.	.96 in.	.94 in.	.94 in.	.97 in.	.98 in.	5.77 in. equals .23 in.
18 ft.	.94 in.	.96 in.	.94 in.	.92 in.	.94 in.	.98 in.	5.68 in. equals .32 in.
20 ft.	.98 in.	.94 in.	.92 in.	.94 in.	.92 in.	.94 in.	5.64 in. equals .36 in.

ANALYSIS.

Table 20—Melt, 24724.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.66	.070	.051	.024	.65
A rail—1	.65	....	.066	.024	.71
2	.67	.084	.070	.030	.837
C rail—1	.66	....	.072	.022	.66
2	.65	.084	.070	.031	.714

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.47 in.	1.68 in.	2.00 in.
Permanent set, base	1.36 in.	1.59 in.	1.88 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.06 in.	1.04 in.	1.06 in.	1.04 in.	1.06 in.	6.30 in. equals .30 in.
18 ft.	1.04 in.	1.06 in.	1.06 in.	1.06 in.	1.04 in.	1.06 in.	6.32 in. equals .32 in.
20 ft.	1.08 in.	1.08 in.	1.06 in.	1.07 in.	1.08 in.	1.04 in.	6.41 in. equals .41 in.

Contraction on Head.

15 ft.	.98 in.	.94 in.	.94 in.	.95 in.	.95 in.	.97 in.	5.73 in. equals .27 in.
18 ft.	......	......	......	......	......	......	5.72 in. equals .28 in.
20 ft.	.98 in.	......	......	.92 in.	.92 in.	.94 in.	5.64 in. equals .36 in.

ANALYSIS.

Table 21—Melt, 21793.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.73	.060	.055	.008	.67
A rail—1	.73	....	.068	.007	.73
2	.74	.075	.084	.009	.824
C rail—1	.72	....	.066	.008	.72
2	.73	.075	.064	.008	.725

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.29 in.	1.56 in.	1.68 in.
Permanent set, base	1.29 in.	1.50 in.	1.57 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.04 in.	1.05 in.	1.05 in.	1.05 in.	1.05 in.	6.27 in. equals .27 in.
18 ft.	1.04 in.	1.04 in.	1.05 in.	1.06 in.	1.04 in.	1.04 in.	6.27 in. equals .27 in.
20 ft.	1.03 in.	1.03 in.	1.06 in.	1.08 in.	1.06 in.	1.04 in.	6.26 in. equals .26 in.

Contraction on Head.

15 ft.	.97 in.	.96 in.	.96 in.	.93 in.	.95 in.	.97 in.	5.74 in. equals .26 in.
18 ft.	.98 in.	.92 in.	......	......	.94 in.	.98 in.	5.71 in. equals .29 in.
20 ft.	.98 in.	.94 in.	.94 in.	.93 in.	.94 in.	.96 in.	5.69 in. equals .31 in.

PENNSYLVANIA STEEL COMPANY—STEELTON MILL.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 22—Melt, 25711.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.64	.070	.035	.009	.77
A rail—1	.62	....	.056	.036	.75
2	.64	.093	.092	.072	.814
C rail—1	.68	....	.038	.016	.73
2	.70	.093	.036	.014	.808

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.58 in.	1.24 in.	1.43 in.
Permanent set, base	1.46 in.	1.20 in.	1.39 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.06 in.	1.04 in.	1.08 in.	1.04 in.	1.06 in.	1.04 in.	6.32 in. equals .32 in.
18 ft.	1.06 in.	1.04 in.	1.04 in.	1.05 in.	1.06 in.	1.03 in.	6.28 in. equals .28 in.
20 ft.	1.04 in.	1.06 in.	1.04 in.	1.06 in.	1.05 in.	1.05 in.	6.31 in. equals .31 in.

Contraction on Head.

15 ft.	.96 in.	.96 in.	.93 in.	.94 in.	.94 in.	.98 in.	5.71 in. equals .29 in.
18 ft.	.98 in.	......	......	......	.96 in.	.98 in.	5.76 in. equals .24 in.
20 ft.	.98 in.	......	......	......	......	.96 in.	5.72 in. equals .28 in.

ANALYSIS.

Table 23—Melt, 25712.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.65	.060	.044	.038	.71
A rail—1	.67	....	.078	.040	.60
2	.64	.075	.060	.038	.649
C rail—1	.64	....	.064	.025	.64
2	.66	.075	.058	.024	.667

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.48 in.	1.74 in.	1.96 in.
Permanent set, base	1.33 in.	1.60 in.	1.76 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.04 in.	1.05 in.	1.05 in.	1.06 in.	1.04 in.	6.29 in. equals .29 in.
18 ft.	1.06 in.	1.04 in.	1.08 in.	1.04 in.	1.06 in.	1.04 in.	6.32 in. equals .32 in.
20 ft.	1.04 in.	1.04 in.	1.06 in.	1.06 in.	1.08 in.	1.06 in.	6.34 in. equals .34 in.

Contraction on Head.

15 ft.	.96 in.	.96 in.	.94 in.	.95 in.	.94 in.	.97 in.	5.72 in. equals .28 in.
18 ft.	.97 in.	.94 in.	.94 in.	.92 in.	.95 in.	.98 in.	5.70 in. equals .30 in.
20 ft.	.97 in.	.96 in.	.93 in.	.93 in.	.93 in.	.96 in.	5.68 in. equals .32 in.

ANALYSIS.

Table 24—Melt, 22748.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.64	.060	.061	.014	.69
A rail—1	.64	....	.076	.015	.65
2	.64	.089	.108	.020	.731
C rail—1	.64	....	.064	.017	.76
2	.64	.075	.090	.019	.773

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.36 in.	1.58 in.	1.82 in.
Permanent set, base	1.28 in.	1.48 in.	1.70 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.06 in.	1.05 in.	1.04 in.	1.05 in.	1.04 in.	6.28 in. equals .28 in.
18 ft.	1.06 in.	1.03 in.	1.06 in.	1.04 in.	1.06 in.	1.06 in.	6.31 in. equals .31 in.
20 ft.	1.06 in.	1.04 in.	1.06 in.	1.06 in.	1.04 in.	1.06 in.	6.32 in. equals .32 in.

Contraction on Head.

15 ft.	.98 in.	.93 in.	.96 in.	.94 in.	.96 in.	.97 in.	5.74 in. equals .26 in.
18 ft.	......	......	......	......	......	......	5.71 in. equals .29 in.
20 ft.	.96 in.	.94 in.	.92 in.	......	......	.96 in.	5.66 in. equals .34 in.

PENNSYLVANIA STEEL COMPANY—STEELTON MILL.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 25—Melt, 24725.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.71	.080	.049	.009	.62
A rail—1	.80	....	.049	.011	.65
2	.82	.112	.085	.016	.763
C rail—1	.81	....	.056	.009	.63
2	.82	.102	.055	.010	.655

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.38 in.	1.68 in.	1.86 in.
Permanent set, base	1.32 in.	1.58 in.	1.76 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.06 in.	1.04 in.	1.05 in.	1.04 in.	1.04 in.	1.04 in.	6.27 in. equals .27 in.
18 ft.	1.07 in.	1.04 in.	1.05 in.	1.06 in.	1.06 in.	1.06 in.	6.34 in. equals .34 in.
20 ft.	1.06 in.	1.06 in.	1.04 in.	1.06 in.	1.04 in.	1.06 in.	6.32 in. equals .32 in.

Contraction on Head.

15 ft.	.96 in.	......	......	......	......	.98 in.	5.72 in. equals .28 in.
18 ft.	.98 in.	......	......	.94 in.	.94 in.	.95 in.	5.70 in. equals .30 in.
20 ft.	......	......	......	......	......	......	5.66 in. equals .34 in.

ANALYSIS.

Table 26—Melt, 24722.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.80	.080	.037	.036	.75
A rail—1	.75	....	.058	.010	.802
2	.78	.102	.068	.014	.916
C rail—1	1.01	....	.047	.027	.73
2	1.02	.094	.046	.030	.808

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.28 in.	1.18 in.	1.31 in.
Permanent set, base	1.16 in.	1.10 in.	1.18 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.06 in.	1.04 in.	1.05 in.	1.03 in.	1.04 in.	1.04 in.	6.26 in. equals .26 in.
18 ft.	1.06 in.	1.04 in.	1.04 in.	1.04 in.	1.04 in.	1.03 in.	6.25 in. equals .25 in.
20 ft.	1.04 in.	1.04 in.	1.02 in.	1.06 in.	1.06 in.	1.06 in.	6.28 in. equals .28 in.

Contraction on Head.

15 ft.	.98 in.	.96 in.	.95 in.	.96 in.	.95 in.	.98 in.	5.78 in. equals .22 in,
18 ft.	.98 in.	......	......	.93 in.	.95 in.	.98 in.	5.80 in. equals .20 in.
20 ft.	.97 in.	.98 in.	.94 in.	.96 in.	.96 in.	.98 in.	5.79 in. equals .21 in

ANALYSIS.

Table 27—Melt, 21792.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.73	.070	.048	.009	.71
A rail—1	.70	....	.056	.009	.73
2	.71	.075	.059	.012	.767
C rail—1	.72	....	.059	.012	.73
2	.72	.093	.059	.010	.761

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.31 in.	1.50 in.	1.64 in.
Permanent set, base	1.21 in.	1.40 in.	1.60 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.06 in.	1.04 in.	1.05 in.	1.04 in.	6.27 in. equals .27 in.
18 ft.	1.06 in.	1.05 in.	1.05 in.	1.05 in.	1.04 in.	1.03 in.	6.28 in. equals .28 in.
20 ft.	1.04 in.	1.08 in.	1.04 in.	1.06 in.	1.05 in.	1.04 in.	6.31 in. equals .31 in.

Contraction on Head.

15 ft.	.98 in.	.95 in.	.95 in.	.95 in.	.94 in.	.98 in.	5.75 in. equals .25 in.
18 ft.	.98 in.	......	......	......	......	......	5.70 in. equals .30 in.
20 ft.	.96 in.	.94 in.	.92 in.	.96 in.	.94 in.	.96 in.	5.68 in. equals .32 in.

PENNSYLVANIA STEEL COMPANY—STEELTON MILL.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 28—Melt, 16005.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.79	.100	.041	.012	.66
A rail—1	.66	....	.059	.009	.73
2	.68	.066	.112	.015	.932
C rail—1	.87	....	.046	.011	.80
2	.88	.066	.050	.014	.802

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.32 in.	1.58 in.	....
Permanent set, base	1.26 in.	1.44 in.	....

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.04 in.	1.04 in.	1.04 in.	1.04 in.	6.24 in. equals .24 in.
18 ft.	1.04 in.	1.06 in.	1.04 in.	1.04 in.	1.04 in.	1.06 in.	6.28 in. equals .24 in.
20 ft.	....	....	....	....	....	....	....

Contraction on Head.

15 ft.	.98 in.	.98 in.	.94 in.	.94 in.	.96 in.	.98 in.	5.78 in. equals .22 in.
18 ft.	.98 in.	.96 in.	.94 in.	.94 in.	.93 in.	.98 in.	5.73 in. equals .27 in.
20 ft.	......	......	......	......	......	......	....

ANALYSIS.

Table 29—Melt, 25715.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.62	.050	.074	.008	.70
A rail—1	.56	....	.088	.010	.61
2	.60	.037	.106	.011	.625
C rail—1	.56	....	.096	.010	.61
2	.56	.047	.094	.009	.629

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set head	1.81 in.	1.98 in.	2.22 in.
Permanent set, base	1.66 in.	1.90 in.	2.08 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.07 in.	1.04 in.	1.08 in.	1.04 in.	1.06 in.	6.33 in. equals .33 in.
18 ft.	1.06 in.	1.06 in.	1.06 in.	1.06 in.	1.06 in.	1.06 in.	6.36 in. equals .36 in.
20 ft.	1.08 in.	1.08 in.	1.08 in.	1.08 in.	1.07 in.	1.06 in.	6.45 in. equals .45 in.

Contraction on Head.

15 ft.	.94 in.	.96 in.	.94 in.	.93 in.	.94 in.	.98 in.	5.69 in. equals .31 in.
18 ft.	.96 in.	.92 in.	.96 in.	.94 in.	.92 in.	.94 in.	5.64 in. equals .36 in.
20 ft.	.98 in.	.92 in.	.94 in.	.92 in.	.94 in.	.97 in.	5.67 in. equals .33 in.

ANALYSIS.

Table 30—Melt, 24727.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.63	.060	.052	.007	.76
A rail—1	.67	....	.058	.009	.73
2	.68	.037	.096	.012	1.020
C rail—1	.63	....	.068	.008	.81
2	.63	.047	.064	.008	.808

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.17 in.	1.42 in.	1.56 in.
Permanent set, base	1.10 in.	1.34 in.	1.40 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.04 in.	1.02 in.	1.02 in.	1.06 in.	6.22 in. equals .22 in.
18 ft.	1.04 in.	1.06 in.	1.04 in.	1.03 in.	1.04 in.	1.06 in.	6.27 in. equals .27 in.
20 ft.	1.04 in.	1.04 in.	1.04 in.	1.04 in.	1.03 in.	1.06 in.	6.25 in. equals .25 in.

Contraction on Head.

15 ft.	.97 in.	.97 in.	.96 in.	.94 in.	.96 in.	.98 in.	5.78 in. equals .22 in.
18 ft.	.98 in.	.96 in.	.94 in.	.94 in.	.96 in.	.98 in.	5.76 in. equals .24 in.
20 ft.	.98 in.	.96 in.	.94 in.	.94 in.	.93 in.	.97 in.	5.72 in. equals .28 in.

NOTES ON CHEMICAL ANALYSIS OF PENNSYLVANIA STEEL COMPANY'S OPEN-HEARTH STEEL RAIL, JULY, 1910.

By

J. H. Gibboney, Chemist.

Standard method of taking drillings. "A" Section from Top Rail. "C" Section from third rail from top.

All Carbons reported in two decimals by Color, in three decimals by Combustion.

TENNESSEE COAL, IRON & R. R. CO.

Open-Hearth Steel Rail—85-lb. A. S. C. E. Section, Rolled for the Winston-Salem Southbound Railway, July, 1910—Tennessee Coal, Iron & Railroad Co.—Ensley Mill, Birmingham, Ala.

On account of economical reasons and the character of the ore used at this plant, the "duplex system" of treatment is followed in the manufacture of Open-Hearth Steel.

Under this process, the metal from blast furnaces is first poured into a large mixer, thence it is passed through Bessemer converters, and afterwards through a tilting type of Open-Hearth furnaces, each of 100 tons capacity. The system of testing employed at this mill, both from a physical and chemical standpoint, is very highly developed; this also for reasons of economy and for uniformity of product.

Nine per cent. minimum discard was aimed at as usual in shearing blooms. The total discard from both blooms and at rail saws varied from 15 to 17 per cent.

ENSLEY MILL—TENNESSEE COAL, IRON AND RAILROAD COMPANY—FOR WINSTON-SALEM SOUTHBOUND RAILWAY COMPANY.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 31—Melt, 10471.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.78	.100	.033	.025	.63
A rail—1	.74	.110	.035	.025	.62
2	.75	.113	.037	.029	.65
C rail—1	.75	.108	.034	.030	.64
2	.75	.110	.035	.030	.65

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.68 in.	1.95 in.	2.25 in.
Permanent set, base	1.56 in.	1.82 in.	2.07 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.06 in.	1.06 in.	1.05 in.	1.05 in.	1.05 in.	6.31 in. equals .31 in.
18 ft.	1.04 in.	1.08 in.	1.06 in.	1.05 in.	1.07 in.	1.05 in.	6.35 in. equals .35 in.
20 ft.	1.07 in.	1.09 in.	1.08 in.	1.10 in.	1.05 in.	1.06 in.	6.45 in. equals .45 in.

Contraction on Head.

15 ft.	.96 in.	.96 in.	.94 in.	.96 in.	.93 in.	.96 in.	5.71 in. equals .29 in.
18 ft.	.94 in.	.92 in.	.95 in.	.91 in.	.96 in.	.98 in.	5.66 in. equals .34 in.
20 ft.	.93 in.	.91 in.	.95 in.	.90 in.	.95 in.	.98 in.	5.62 in. equals .38 in.

ENSLEY MILL—TENNESSEE COAL, IRON AND RAILROAD COMPANY—FOR WINSTON-SALEM SOUTHBOUND RAILWAY COMPANY.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 32—Melt, 60463.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.65	....	.031	.031	.63
A rail—1	.63	.110	.034	.032	.64
2	.63	.113	.032	.037	.62
C rail—1	.62	.098	.038	.033	.63
2	.64	.100	.044	.039	.65

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.76 in.	2.14 in.	2.27 in.
Permanent set, base	1.68 in.	2.00 in.	2.12 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.06 in.	1.06 in.	1.06 in.	1.06 in.	1.06 in.	1.06 in.	6.36 in. equals .36 in.
18 ft.	1.05 in.	1.09 in.	1.08 in.	1.07 in.	1.06 in.	1.05 in.	6.40 in. equals .40 in.
20 ft.	1.07 in.	1.10 in.	1.07 in.	1.07 in.	1.07 in.	1.05 in.	6.43 in. equals .43 in.

Contraction on Head.

15 ft.	.95 in.	.92 in.	.94 in.	.95 in.	.95 in.	.96 in.	5.67 in. equals .33 in.
18 ft.	.94 in.	.91 in.	.92 in.	.92 in.	.91 in.	.97 in.	5.57 in. equals .43 in.
20 ft.	.92 in.	.92 in.	.95 in.	.91 in.	.94 in.	.98 in.	5.62 in. equals .38 in.

ANALYSIS.

Table 33—Melt, 40484.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.73	.088	.038	.025	.65
A rail—1	.70	.093	.030	.033	.63
2	.71	.100	.038	.037	.67
C rail—1	.69	.090	.036	.032	.63
2	.69	.092	.042	.034	.67

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.46 in.	1.96 in.	2.20 in.
Permanent set, base	1.30 in.	1.85 in.	2.08 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.08 in.	1.05 in.	1.06 in.	1.05 in.	1.06 in.	6.34 in. equals .34 in.
18 ft.	1.04 in.	1.08 in.	1.07 in.	1.08 in.	1.07 in.	1.06 in.	6.40 in. equals .40 in.
20 ft.	1.06 in.	1.08 in.	1.08 in.	1.10 in.	1.06 in.	1.07 in.	6.45 in. equals .45 in.

Contraction on Head.

15 ft.	.96 in.	.96 in.	.96 in.	.93 in.	.94 in.	.98 in.	5.73 in. equals .27 in.
18 ft.	.97 in.	.91 in.	.95 in.	.94 in.	.93 in.	.95 in.	5.65 in. equals .35 in.
20 ft.	.95 in.	.91 in.	.95 in.	.93 in.	.92 in.	.98 in.	5.64 in. equals .36 in.

ANALYSIS.

Table 34—Melt, 50462.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.72	.113	.042	.040	.71
A rail—1	.69	.093	.038	.045	.67
2	.69	.110	.038	.046	.69
C rail—1	.70	.113	.038	.042	.67
2	.69	.120	.038	.045	.67

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.64 in.	1.85 in.	2.13 in.
Permanent set, base	1.50 in.	1.72 in.	1.98 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.06 in.	1.07 in.	1.05 in.	1.06 in.	1.05 in.	6.34 in. equals .34 in.
18 ft.	1.05 in.	1.04 in.	1.07 in.	1.05 in.	1.07 in.	1.06 in.	6.34 in. equals .34 in.
20 ft.	1.06 in.	1.08 in.	1.08 in.	1.09 in.	1.04 in.	1.07 in.	6.42 in. equals .42 in.

Contraction on Head.

15 ft.	.98 in.	.94 in.	.94 in.	.93 in.	.96 in.	.96 in.	5.71 in. equals .29 in.
18 ft.	.98 in.	.92 in.	.92 in.	.93 in.	.93 in.	.98 in.	5.66 in. equals .34 in.
20 ft.	.94 in.	.91 in.	.96 in.	.90 in.	.95 in.	.98 in.	5.64 in. equals .36 in.

ENSLEY MILL—TENNESSEE COAL, IRON AND RAILROAD COMPANY—FOR WINSTON-SALEM SOUTHBOUND RAILWAY COMPANY.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 35—Melt, 50464.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.68	.113	.040	.031	.68
A rail—1	.67	.112	.042	.032	.63
2	.68	.120	.046	.036	.65
C rail—1	.68	.108	.046	.034	.65
2	.69	.110	.044	.035	.67

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.69 in.	2.01 in.	2.20 in.
Permanent set, base	1.60 in.	1.90 in.	2.08 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.06 in.	1.06 in.	1.05 in.	1.03 in.	1.05 in.	6.30 in. equals .30 in.
18 ft.	1.07 in.	1.10 in.	1.06 in.	1.08 in.	1.03 in.	1.06 in.	6.40 in. equals .40 in.
20 ft.	1.06 in.	1.10 in.	1.05 in.	1.08 in.	1.06 in.	1.06 in.	6.41 in. equals .41 in.

Contraction on Head.

15 ft.	.97 in.	.94 in.	.93 in.	.92 in.	.95 in.	.96 in.	5.67 in. equals .33 in.
18 ft.	.93 in.	.94 in.	.95 in.	.92 in.	.96 in.	.99 in.	5.69 in. equals .31 in.
20 ft.	.94 in.	.91 in.	.95 in	.93 in.	.92 in.	.98 in.	5.63 in. equals .37 in.

ANALYSIS.

Table 36—Melt, 10470.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.70	.080	.031	.031	.75
A rail—1	.68	.090	.028	.028	.69
2	.70	.093	.036	.030	.72
C rail—1	.68	.086	.032	.030	.72
2	.68	.088	.036	.031	.73

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.52 in.	1.84 in.	2.10 in.
Permanent set, base	1.46 in.	1.73 in.	1.96 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.06 in.	1.05 in.	1.06 in.	1.04 in.	1.06 in.	6.31 in. equals .31 in.
18 ft.	1.06 in.	1.08 in.	1.05 in.	1.07 in.	1.05 in.	1.06 in.	6.37 in. equals .37 in.
20 ft.	1.10 in.	1.07 in.	1.09 in.	1.08 in.	1.06 in.	1.06 in.	6.46 in. equals .46 in.

Contraction on Head.

15 ft.	.97 in.	.94 in.	.96 in.	.97 in.	.94 in.	.97 in.	5.75 in. equals .25 in.
18 ft.	.95 in.	.92 in.	.95 in.	.92 in.	.93 in.	.99 in.	5.66 in. equals .34 in.
20 ft.	.96 in.	.91 in.	.96 in.	.90 in.	.95 in.	.99 in.	5.67 in. equals .33 in.

ANALYSIS.

Table 37—Melt, 40485.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.69	.098	.031	.033	.63
A rail—1	.62	.106	.028	.029	.61
2	.67	.110	.032	.035	.62
C rail—1	.67	.108	.032	.033	.62
2	.62	.109	.038	.035	.65

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.71 in.	2.04 in.	2.25 in.
Permanent set, base	1.60 in.	1.90 in.	2.10 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.05 in.	1.07 in.	1.04 in.	1.05 in.	1.01 in.	6.27 in. equals .27 in.
18 ft.	1.05 in.	1.08 in.	1.07 in.	1.08 in.	1.05 in.	1.05 in.	6.38 in. equals .38 in.
20 ft.	1.07 in.	1.07 in.	1.10 in.	1.06 in.	1.08 in.	1.07 in.	6.45 in. equals .45 in.

Contraction on Head.

15 ft.	.95 in.	.96 in.	.91 in.	.94 in.	.92 in.	.97 in.	5.65 in. equals .35 in.
18 ft.	.95 in.	.92 in.	.95 in.	.93 in.	.93 in.	.98 in.	5.66 in. equals .34 in.
20 ft.	.96 in.	.90 in.	.97 in.	.89 in.	.93 in.	.98 in.	5.63 in. equals .37 in

ENSLEY MILL—TENNESSEE COAL, IRON AND RAILROAD COMPANY—FOR WINSTON-SALEM SOUTHBOUND RAILWAY COMPANY.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 38—Melt, 50463.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.63	.111	.031	.030	.61
A rail—1.............	.60	.140	.030	.035	.64
2.............	.62	.143	.032	.036	.62
C rail—1.............	.59	.120	.028	.035	.63
2.............	.60	.122	.030	.036	.64

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.70 in.	1.95 in.	2.35 in.
Permanent set, base..................	1.61 in.	1.83 in.	2.17 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.04 in.	1.07 in.	1.06 in.	1.02 in.	6.27 in. equals .27 in.
18 ft.	1.07 in.	1.05 in.	1.06 in.	1.07 in.	1.06 in.	1.07 in.	6.38 in. equals .38 in.
20 ft.	1.08 in.	1.08 in.	1.10 in.	1.08 in.	1.09 in.	1.05 in.	6.48 in. equals .48 in.

Contraction on Head.

15 ft.	.97 in.	.94 in.	.94 in.	.92 in.	.94 in.	.94 in.	5.65 in. equals .35 in.
18 ft.	.95 in.	.92 in.	.94 in.	.95 in.	.91 in.	.98 in.	5.65 in. equals .35 in.
20 ft.	.95 in.	.90 in.	.95 in.	.90 in.	.95 in.	.97 in.	5.62 in. equals .38 in.

ANALYSIS.

Table 39—Melt, 60465.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.71	....	.038	.028	.70
A rail—1.............	.67	.108	.032	.029	.69
2.............	.69	.106	.034	.031	.72
C rail—1.............	.68	.110	.032	.031	.70
2.............	.69	.104	.034	.033	.72

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.54 in.	1.92 in.	2.15 in.
Permanent set, base..................	1.44 in.	1.80 in.	2.02 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.06 in.	1.05 in.	1.05 in.	1.03 in.	1.02 in.	6.24 in. equals .24 in.
18 ft.	1.05 in.	1.08 in.	1.06 in.	1.07 in.	1.06 in.	1.05 in.	6.37 in. equals .37 in.
20 ft.	1.07 in.	1.08 in.	1.06 in.	1.08 in.	1.04 in.	1.05 in.	6.38 in. equals .38 in.

Contraction on Head.

15 ft.	.96 in.	.95 in.	.93 in.	.95 in.	.96 in.	.98 in.	5.63 in. equals .27 in.
18 ft.	.95 in.	.91 in.	.95 in.	.92 in.	.93 in.	.99 in.	5.65 in. equals .35 in.
20 ft.	.93 in.	.92 in.	.95 in.	.93 in.	.94 in.	.97 in.	5.64 in. equals .36 in.

ANALYSIS.

Table 40—Melt, 60464.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.69	.104	.030	.022	.61
A rail—1.............	.66	.112	.030	.022	.59
2.............	.70	.110	.032	.021	.60
C rail—1.............	.67	.106	.034	.024	.60
2.............	.70	.108	.031	.025	.62

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.76 in.	2.30 in.	2.50 in.
Permanent set, base..................	1.71 in.	2.15 in.	2.30 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.08 in.	1.08 in.	1.06 in.	1.04 in.	1.06 in.	6.36 in. equals .36 in.
18 ft.	1.07 in.	1.10 in.	1.08 in.	1.08 in.	1.06 in.	1.07 in.	6.46 in. equals .46 in.
20 ft.	1.08 in.	1.11 in.	1.08 in.	1.09 in.	1.07 in.	1.07 in.	6.50 in. equals .50 in.

Contraction on Head.

15 ft.	.94 in.	.94 in.	.96 in.	.90 in.	.95 in.	.98 in.	5.67 in. equals .33 in.
18 ft.	.95 in.	.89 in.	.94 in.	.94 in.	.90 in.	.98 in.	5.60 in. equals .40 in.
20 ft.	.90 in.	.93 in.	.92 in.	.90 in.	.94 in.	.98 in.	5.57 in. equals .43 in.

ENSLEY MILL—TENNESSEE COAL, IRON AND RAILROAD COMPANY—FOR WINSTON-SALEM SOUTHBOUND RAILWAY COMPANY.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

July, 1910.

ANALYSIS.

Table 41—Melt, 10472.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.70	.109	.037	.021	.65
A rail—1.............	.70	.112	.036	.020	.65
2.............	.70	.116	.038	.022	.67
C rail—1.............	.68	.108	.035	.020	.63
2.............	.68	.110	.036	.022	.66

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.78 in.	2.00 in.	2.41 in.
Permanent set, base..................	1.66 in.	1.88 in.	2.24 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.05 in.	1.07 in.	1.07 in.	1.05 in.	1.04 in.	6.33 in. equals .33 in.
18 ft.	1.07 in.	1.06 in.	1.05 in.	1.09 in.	1.05 in.	1.06 in.	6.38 in. equals .38 in.
20 ft.	1.09 in.	1.08 in.	1.11 in.	1.06 in.	1.10 in.	1.05 in.	6.49 in. equals .49 in.

Contraction on Head.

15 ft.	.94 in.	.92 in.	.94 in.	.94 in.	.93 in.	.96 in.	5.63 in. equals .37 in.
18 ft.	.97 in.	.90 in.	.93 in.	.97 in.	.90 in.	.95 in.	5.62 in. equals .38 in.
20 ft.	.95 in.	.90 in.	.98 in.	.89 in.	.92 in.	.97 in.	5.61 in. equals .39 in.

ANALYSIS.

Table 42—Melt, 20449.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.72	....	.033	.018	.68
A rail—1.............	.69	.090	.036	.018	.69
2.............	.70	.093	.031	.019	.69
C rail—1.............	.69	.088	.036	.020	.70
2.............	.70	.090	.036	.023	.72

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop
Permanent set, head..................	1.64 in.	1.95 in.	2.11 in.
Permanent set, base..................	1.50 in.	1.75 in.	1.98 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.08 in.	1.07 in.	1.05 in.	1.05 in.	1.04 in.	6.33 in. equals .33 in.
18 ft.	1.05 in.	1.06 in.	1.09 in.	1.05 in.	1.08 in.	1.07 in.	6.40 in. equals .40 in.
20 ft.	1.10 in.	1.06 in.	1.09 in.	1.04 in.	1.05 in.	1.03 in.	6.37 in. equals .37 in.

Contraction on Head.

15 ft.	.97 in.	.96 in.	.93 in.	.93 in.	.94 in.	.97 in.	5.70 in. equals .30 in.
18 ft.	.98 in.	.93 in.	.95 in.	.94 in.	.92 in.	.97 in.	5.69 in. equals .31 in.
20 ft.	.97 in.	.90 in.	.95 in.	.92 in.	.93 in.	.97 in.	5.64 in. equals .36 in.

NOTES ON CHEMICAL ANALYSIS OF ENSLEY MILL OPEN-HEARTH STEEL RAIL, JULY, 1910.

By

J. H. Gibboney, Chemist.

From a comparison of our results with those reported by the Mill people a very close agreement in all heats is noted. It is also noted that all twelve heats show close agreement among themselves, giving a uniform product for this rolling.

Standard method observed for taking drillings.

All Carbons run by color method, using Penn. Steel Company's

0.73 per cent. Carbon O. H. Steel Rail for comparison. Several samples were checked up by combustion with no noticeable variation from the color figure.

BETHLEHEM STEEL COMPANY.

OPEN-HEARTH STEEL RAIL—85-LB. A. S. C. E. SECTION, ROLLED FOR THE NORFOLK & WESTERN RAILWAY, AUGUST, 1910—BETHLEHEM STEEL WORKS, SOUTH BETHLEHEM, PA.

Rails rolled without reheating from ingot to finished rail.

The average discard from blooms ranged from 19 to 22 per cent.; that at saws was fully 3 per cent. Total averaged from 22 to 25 per cent.

BETHLEHEM STEEL COMPANY.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

August, 1910.

ANALYSIS.

Table 43—Melt, B-20428.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.62	....	.040	.022	.63
Top—1	.61	....	.034	.023	.70
2	.63	.149	.031	.021	.69
Bottom—1	.61	....	.032	.023	.69
2	.61	.121	.032	.021	.69

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.55 in.	1.77 in.	1.87 in.
Permanent set, base	1.48 in.	1.71 in.	1.77 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.04 in.	1.06 in.	1.05 in.	1.06 in.	1.03 in.	6.29 in. equals .29 in.
18 ft.	1.06 in.	1.05 in.	1.07 in.	1.06 in.	1.07 in.	1.02 in.	6.33 in. equals .33 in.
20 ft.	1.04 in.	1.06 in.	1.08 in.	1.07 in.	1.08 in.	1.04 in.	6.37 in. equals .37 in.

Contraction on Head.

15 ft.	.96 in.	.94 in.	.95 in.	.93 in.	.96 in.	.97 in.	5.71 in. equals .29 in.
18 ft.	.97 in.	.93 in.	.94 in.	.95 in.	.93 in.	.95 in.	5.67 in. equals .33 in.
20 ft.	.96 in.	.95 in.	.92 in.	.95 in.	.93 in.	.93 in.	5.64 in. equals .36 in.

ANALYSIS.

Table 44—Melt, B-16472.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.77	....	.041	.023	.65
Top—1	.69	....	.020	.023	.68
2	.72	.093	.024	.029	.66
Bottom—1	.70	....	.016	.026	.68
2	.70	.066	.016	.025	.68

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.28 in.	1.55 in.	1.74 in.
Permanent set, base	1.23 in.	1.47 in.	1.65 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.06 in.	1.03 in.	1.05 in.	1.05 in.	1.06 in.	1.01 in.	6.26 in. equals .26 in.
18 ft.	1.05 in.	1.03 in.	1.05 in.	1.06 in.	1.07 in.	1.03 in.	6.29 in. equals .29 in.
20 ft.	1.05 in.	1.05 in.	1.07 in.	1.07 in.	1.07 in.	1.03 in.	6.34 in. equals .34 in.

Contraction on Head.

15 ft.	.98 in.	.95 in.	.95 in.	.95 in.	.95 in.	.96 in.	5.74 in. equals .26 in.
18 ft.	.97 in.	.96 in.	.93 in.	.95 in.	.95 in.	.93 in.	5.69 in. equals .31 in.
20 ft.	.96 in.	.94 in.	.93 in.	.95 in.	.93 in.	.93 in.	5.64 in. equals .36 in.

BETHLEHEM STEEL COMPANY.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

August, 1910.

ANALYSIS.

Table 45—Melt, B-20427.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon
Mill report...........	.65	....	.044	.021	.74
Top—1	.93	....	.027	.023	.88
2	.92	.130	.024	.030	.88
Bottom—1	.92	....	.022	.024	.84
2	.95	.130	.022	.030	.88

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop
Permanent set, head..................	.99 in.	1.35 in.	1.47 in.
Permanent set, base..................	.97 in.	1.27 in.	1.40 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.02 in.	1.04 in.	1.04 in.	1.05 in.	1.01 in.	6.21 in. equals .21 in.
18 ft.	1.05 in.	1.04 in.	1.05 in.	1.05 in.	1.06 in.	1.02 in.	6.27 in. equals .27 in.
20 ft.	1.02 in.	1.06 in.	1.04 in.	1.06 in.	1.04 in.	1.04 in.	6.26 in. equals .26 in

Contraction on Head.

15 ft.	.97 in.	.97 in.	.95 in.	.96 in.	.97 in.	.97 in.	5.79 in. equals .21 in.
18 ft.	.97 in.	.95 in.	.95 in.	.96 in.	.96 in.	.95 in.	5.74 in. equals .26 in.
20 ft.	.95 in.	.95 in.	.96 in.	.93 in.	.95 in.	.96 in.	5.70 in. equals .30 in.

ANALYSIS.

Table 46—Melt, B-19383.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.78	.087	.037	.023	.67
Top—1	.79	....	.028	.023	.72
2	.80	.120	.030	.023	.72
Bottom—1	.78	....	.026	.023	.72
2	.78	.102	.027	.024	.74

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.30 in.	1.47 in.	1.67 in.
Permanent set, base..................	1.22 in.	1.36 in.	1.58 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.03 in.	1.05 in.	1.04 in.	1.06 in.	1.02 in.	6.25 in. equals .25 in.
18 ft.	1.04 in.	1.04 in.	1.06 in.	1.05 in.	1.06 in.	1.02 in.	6.27 in. equals .27 in.
20 ft.	1.02 in.	1.07 in.	1.06 in.	1.07 in.	1.05 in.	1.05 in.	6.32 in. equals .32 in.

Contraction on Head.

15 ft.	.98 in.	.97 in.	.94 in.	.98 in.	.95 in.	.95 in.	5.67 in. equals .23 in.
18 ft.	.98 in.	.94 in.	.95 in.	.96 in.	.95 in.	.94 in.	5.72 in. equals .28 in.
20 ft.	.94 in.	.94 in.	.95 in.	.93 in.	.93 in.	.95 in.	5.64 in. equals .36 in

ANALYSIS.

Table 47—Melt, P-2246.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.60	.147	.036	.029	.63
Top—1	.63	....	.043	.030	.62
2	.64	.121	.043	.029	.62
Bottom—1	.64	....	.037	.026	.61
2	.64	.112	.036	.026	.61

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.43 in.	1.80 in.	2.03 in.
Permanent set, base..................	1.38 in.	1.70 in.	1.97 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.07 in.	1.05 in.	1.07 in.	1.05 in.	1.07 in.	1.02 in.	6.33 in. equals .33 in.
18 ft.	1.08 in.	1.06 in.	1.08 in.	1.06 in.	1.08 in.	1.03 in.	6.39 in. equals .39 in
20 ft.	1.05 in.	1.04 in.	1.06 in.	1.08 in.	1.10 in.	1.04 in.	6.37 in. equals .37 in.

Contraction on Head.

15 ft.	.96 in.	.94 in.	.96 in.	.94 in.	.97 in.	.95 in.	5.72 in. equals .28 in.
18 ft.	.96 in.	.93 in.	.92 in.	.95 in.	.93 in.	.93 in.	5.62 in. equals .38 in.
20 ft.	.97 in.	.95 in.	.92 in.	.95 in.	.93 in.	.90 in.	5.62 in. equals .38 in.

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ANALYSIS.

Table 48—Melt, B-17549.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.80	....	.041	.025	.67
Top—1	.81	....	.038	.022	.74
2	.80	.093	.035	.026	.74
Bottom—1	.80	....	.036	.024	.70
2	.80	.084	.034	.026	.70

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.27 in.	1.56 in.	1.63 in.
Permanent set, base	1.22 in.	1.47 in.	1.54 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.06 in.	1.04 in.	1.05 in.	1.05 in.	1.06 in.	1.02 in.	6.28 in. equals .28 in.
18 ft.	1.05 in.	1.04 in.	1.06 in.	1.05 in.	1.07 in.	1.03 in.	6.30 in. equals .30 in.
20 ft.	1.04 in.	1.04 in.	1.06 in.	1.05 in.	1.07 in.	1.03 in.	6.29 in. equals .29 in.

Contraction on Head.

15 ft.	.94 in.	.95 in.	.96 in.	.97 in.	.96 in.	.94 in.	5.72 in. equals .28 in.
18 ft.	.97 in.	.95 in.	.95 in.	.95 in.	.94 in.	.93 in.	5.69 in. equals .31 in.
20 ft.	.97 in.	.96 in.	.93 in.	.95 in.	.95 in.	.93 in.	5.69 in. equals .31 in.

ANALYSIS.

Table 49—Melt, E-972.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.80	....	.042	.026	.68
Top—1	.79	....	.032	.032	.72
2	.79	.130	.030	.030	.72
Bottom—1	.81	....	.030	.031	.73
2	.82	.130	.030	.030	.73

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.27 in.	1.55 in.	1.63 in.
Permanent set, base	1.18 in.	1.46 in.	1.55 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.03 in.	1.04 in.	1.05 in.	1.05 in.	1.02 in.	6.24 in. equals .24 in.
18 ft.	....	....	....	....	....	....	....
20 ft.	1.02 in.	1.07 in.	1.06 in.	1.07 in.	1.06 in.	1.05 in.	6.33 in. equals .33 in.

Contraction on Head.

15 ft.	.97 in.	.95 in.	.94 in.	.97 in.	.95 in.	.95 in.	5.63 in. equals .27 in.
18 ft.	.96 in.	.93 in.	.95 in.	.95 in.	.94 in.	.95 in.	5.68 in. equals .32 in.
20 ft.	.96 in.	.96 in.	.93 in.	.97 in.	.93 in.	.94 in.	5.69 in. equals .31 in.

ANALYSIS.

Table 50—Melt, B-21437.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.77	.119	.031	.020	.68
Top—1	.82	....	.031	.017	.73
2	.85	.168	.031	.018	.74
Bottom—1	.80	....	.029	.018	.74
2	.83	.121	.027	.017	.73

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.19 in.	1.50 in.	1.57 in.
Permanent set, base	1.14 in.	1.43 in.	1.52 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.02 in.	1.05 in.	1.04 in.	1.06 in.	1.02 in.	6.24 in. equals .24 in.
18 ft.	1.06 in.	1.05 in.	1.06 in.	1.04 in.	1.07 in.	1.02 in.	6.30 in. equals .30 in.
20 ft.	1.04 in.	1.04 in.	1.06 in.	1.06 in.	1.08 in.	1.03 in.	6.31 in. equals .31 in.

Contraction on Head.

15 ft.	.98 in.	.95 in.	.95 in.	.97 in.	.97 in.	.95 in.	5.77 in. equals .23 in.
18 ft.	.97 in.	.95 in.	.93 in.	.96 in.	.94 in.	.95 in.	5.70 in. equals .30 in.
20 ft.	.98 in.	.95 in.	.93 in.	.96 in.	.93 in.	.94 in.	5.69 in. equals .31 in.

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Table 51—Melt, B-16470.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.62	....	.034	.020	.63
Top—1	.67	....	.029	.018	.66
2	.67	.093	.035	.017	.67
Bottom—1	.67	....	.035	.018	.66
2	.66	.080	.033	.018	.66

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop
Permanent set, head..................	1.45 in.	1.73 in.	1.96 in.
Permanent set, base..................	1.36 in.	1.65 in.	1.85 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.04 in.	1.05 in.	1.04 in.	1.06 in.	1.02 in.	6.26 in. equals .26 in.
18 ft.	1.05 in.	1.05 in.	1.07 in.	1.05 in.	1.07 in.	1.04 in.	6.33 in. equals .33 in.
20 ft.	1.07 in.	1.04 in.	1.08 in.	1.08 in.	1.08 in.	1.03 in.	6.38 in. equals .38 in.

Contraction on Head.

15 ft.	.97 in.	.93 in.	.95 in.	.95 in.	.95 in.	.93 in.	5.68 in. equals .32 in.
18 ft.	.96 in.	.94 in.	.93 in.	.95 in.	.94 in.	.94 in.	5.66 in. equals .34 in.
20 ft.	.96 in.	.94 in.	.92 in.	.94 in.	.93 in.	.93 in.	5.62 in. equals .38 in.

ANALYSIS.

Table 52—Melt, E-971.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.61	.140	.036	.028	.67
Top—1	.72	....	.033	.031	.68
2	.70	.140	.030	.033	.72
Bottom—1	.70	....	.017	.031	.70
2...........	.70	.121	.017	.033	.73

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.31 in.	1.59 in.	1.75 in.
Permanent set, base..................	1.26 in.	1.53 in.	1.67 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.02 in.	1.05 in.	1.05 in.	1.07 in.	1.02 in.	6.24 in. equals .24 in.
18 ft.	1.06 in.	1.03 in.	1.06 in.	1.06 in.	1.07 in.	1.02 in.	6.30 in. equals .30 in.
20 ft.	1.06 in.	1.05 in.	1.07 in.	1.06 in.	1.08 in.	1.02 in.	6.34 in. equals .34 in.

Contraction on Head.

15 ft.	.97 in.	.93 in.	.96 in.	.96 in.	.92 in.	.95 in.	5.69 in. equals .31 in.
18 ft.	.97 in.	.94 in.	.94 in.	.96 in.	.94 in.	.94 in.	5.69 in. equals .31 in.
20 ft.	.96 in.	.92 in.	.96 in.	.96 in.	.93 in.	.95 in.	5.68 in. equals .32 in.

ANALYSIS.

Table 53—Melt, B-17548.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.79	.100	.041	.023	.74
Top—1	.78	....	.035	.018	.74
2	.78	.180	.035	.025	.73
Bottom—1	.78	....	.028	.010	.72
2	.79	.180	.030	.013	.73

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.18 in.	1.37 in.	1.39 in.
Permanent set, base..................	1.12 in.	1.27 in.	1.33 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.02 in.	1.06 in.	1.04 in.	1.05 in.	1.02 in.	6.23 in. equals .23 in.
18 ft.	1.06 in.	1.04 in.	1.05 in.	1.04 in.	1.06 in.	1.02 in.	6.27 in. equals .27 in.
20 ft.	1.05 in.	1.03 in.	1.05 in.	1.05 in.	1.07 in.	1.02 in.	6.27 in. equals .27 in.

Contraction on Head.

15 ft.	.98 in.	.94 in.	.94 in.	94 in.	.95 in.	.94 in.	5.69 in equals .31 in.
18 ft.	.97 in.	.95 in.	.93 in	.97 in.	.95 in	.97 in.	5.74 in. equals .26 in.
20 ft.	.97 in.	.95 in.	.93 in.	.96 in.	.94 in.	.95 in.	5.70 in. equals .30 in.

BETHLEHEM STEEL COMPANY.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

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ANALYSIS.

Table 54—Melt, B-20426.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.80	.183	.041	.022	.69
Top—1	.80	....	.033	.023	.74
2	.80	.187	.032	.022	.75
Bottom—1	.78	....	.023	.018	.69
2	.77	.168	.023	.021	.70

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.22 in.	1.50 in.	1.66 in.
Permanent set, base..................	1.16 in.	1.41 in.	1.61 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.03 in.	1.04 in.	1.04 in.	1.06 in.	1.02 in.	6.23 in. equals .23 in.
18 ft.	1.06 in.	1.03 in.	1.06 in.	1.04 in.	1.07 in.	1.03 in.	6.29 in. equals .29 in.
20 ft.	1.05 in.	1.05 in.	1.07 in.	1.05 in.	1.08 in.	1.02 in.	6.32 in. equals .32 in.

Contraction on Head.

15 ft.	.97 in.	.95 in.	.94 in.	.96 in.	.97 in.	.96 in.	5.75 in. equals .25 in.
18 ft.	.98 in.	.95 in.	.93 in.	.95 in.	.95 in.	.94 in.	5.70 in. equals .30 in.
20 ft.	.96 in.	.93 in.	.94 in.	.93 in.	.95 in.	.95 in.	5.66 in. equals .34 in.

ANALYSIS.

Table 55—Melt, B-16469.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.74	.083	.040	.023	.70
Top—1	.75	....	.027	.021	.70
2	.80	.121	.028	.025	.73
Bottom—1	.97	....	.020	.026	.80
2	.97	.112	.031	.026	.82

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.23 in.	1.50 in.	1.64 in.
Permanent set, base..................	1.20 in.	1.44 in.	1.52 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.02 in.	1.06 in.	1.04 in.	1.05 in.	1.06 in.	1.03 in.	6.26 in. equals .26 in.
18 ft.	1.06 in.	1.05 in.	1.06 in.	1.04 in.	1.06 in.	1.02 in.	6.29 in. equals .29 in.
20 ft.	1.05 in.	1.03 in.	1.07 in.	1.05 in.	1.07 in.	1.03 in.	6.30 in. equals .30 in.

Contraction on Head.

15 ft.	.97 in.	.97 in.	.93 in.	.95 in.	.94 in.	.96 in.	5.72 in. equals .28 in.
18 ft.	.96 in.	.92 in.	.97 in.	.92 in.	.96 in.	.97 in.	5.70 in. equals .30 in.
20 ft.	.96 in.	.94 in.	.94 in.	.95 in.	.93 in.	.95 in.	5.67 in. equals .33 in.

ANALYSIS.

Table 56—Melt, B-16468.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.72	.136	.037	.028	.64
Top—1	.68	....	.042	.022	.60
2	.68	.102	.041	.022	.64
Bottom—1	.67	....	.037	.021	.63
2	.67	.093	.039	.022	.63

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.58 in.	1.92 in.	2.30 in.
Permanent set, base..................	1.50 in.	1.80 in.	2.16 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.06 in.	1.04 in.	1.08 in.	1.04 in.	1.06 in.	1.04 in.	6.32 in. equals .32 in.
18 ft.	1.03 in.	1.08 in.	1.06 in.	1.07 in.	1.05 in.	1.06 in.	6.35 in. equals .35 in
20 ft.	1.04 in.	1.09 in.	1.08 in.	1.09 in.	1.07 in.	1.08 in.	6.45 in. equals .45 in.

Contraction on Head.

15 ft.	.95 in.	.93 in.	.93 in.	.93 in.	.96 in.	.95 in.	5.65 in. equals .35 in.
18 ft.	.93 in.	.93 in.	.93 in.	.93 in.	.93 in.	.97 in.	5.62 in. equals .38 in
20 ft.	.93 in.	.93 in.	.90 in.	.93 in.	.89 in.	.93 in.	5.51 in. equals .49 in.

BETHLEHEM STEEL COMPANY.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

August, 1910.

ANALYSIS.

Table 57—Melt, L-2048.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.79	.154	.038	.021	.64
Top—1	.82	....	.038	.030	.68
2	.82	.159	.043	.030	.68
Bottom—1	.82	....	.042	.020	.72
2	.82	.159	.041	.026	.72

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.26 in.	1.50 in.	1.63 in.
Permanent set, base	1.19 in.	1.44 in.	1.54 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.02 in.	1.05 in.	1.05 in.	1.05 in.	1.02 in.	6.23 in. equals .23 in.
18 ft.	1.06 in.	1.04 in.	1.06 in.	1.06 in.	1.06 in.	1.02 in.	6.30 in. equals .30 in.
20 ft.	1.05 in.	1.05 in.	1.07 in.	1.08 in.	1.07 in.	1.03 in.	6.35 in. equals .35 in.

Contraction on Head.

15 ft.	.97 in.	.96 in.	.94 in.	.97 in.	.96 in.	.94 in.	5.74 in. equals .26 in.
18 ft.	.94 in.	.92 in.	.96 in.	.92 in.	.98 in.	.96 in.	5.68 in. equals .32 in.
20 ft.	.97 in.	.95 in.	.92 in.	.96 in.	.94 in.	.94 in.	5.68 in. equals .32 in.

NOTES ON CHEMICAL ANALYSIS OF BETHLEHEM OPEN-HEARTH STEEL RAIL, AUGUST, 1910.

By

J. H. Gibboney, Chemist.

N. & W. standard method of taking drillings as shown on Fig. 1.

Carbons by Color Method—Standard open-hearth steel rail used for comparisons.

Heat B-16468—This heat uniform and our results show close agreement with mill analysis.

Heat 16469—The top shows very close agreement between our result and the mill analysis. The bottom of ingot shows a decided increase in Manganese and Carbon.

Heat 20426—This heat shows very close agreement between our results and the mill analysis.

Heat L-2048—This heat shows a very good agreement, the Carbons in our results being slightly higher.

Heat B-17548—This heat shows very close agreement.

Heat E-971—This heat shows very good agreement.

Heat B-16470—This heat shows very good agreement.

Heat B-21437—This heat shows very good agreement.

Heat E-972—This heat shows very good agreement.

Heat B-17549—This heat shows very good agreement.

Heat P-2246—This heat shows very good agreement.

Heat B-19383—This heat shows very good agreement.

Heat B-20427—This heat shows much higher Manganese and Carbon contents on our determinations. From physical tests made it will be noted that this is the stiffest rail in the whole number.

Heat B-16472—This heat shows very good agreement.

Heat B-20428—This heat shows very good agreement, our Carbons being slightly higher than the mill.

Taken as a whole the above heats represent very good steel, and the agreement of our work with the reported mill examinations is very good.

MARYLAND STEEL CO.

Open-Hearth Steel Rail, 85-lb. A. S. C. E., Rolled for the Norfolk & Western Railway, October, 1910—Maryland Steel Company, Sparrows Point, Md.

The average discard from blooms averaged: Top, 8 per cent.; bottom, 7 per cent.; at saws, 4 per cent.; total discard averaged 19 per cent.

Note.—The test pieces "A" rail from this mill were cut from the *bottom* end of "A" rails, instead of from extreme top end.

MARYLAND STEEL CO.'S MILL—SPARROWS POINT, MD.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

October, 1910.

ANALYSIS.

Table 58—Melt, 3446.

Position.	Mn.	Si.	S.	P.	C.	Cr.	Ni.
Mill report	.63	.052	.049	.012	.66	.17	.48
A rail—1	.82	....	.067	.012	.66	...	...
2	.81	.038	.077	.010	.72	...	...
D rail—1	.56	....	.055	.010	.63	...	...
2	.57	.038	.055	.010	.64	...	...

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.36 in.	1.47 in.	1.52 in.
Permanent set, base	1.31 in.	1.41 in.	1.43 in.

Contraction on Head.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.04 in.	1.04 in.	1.05 in.	1.06 in.	1.02 in.	6.24 in. equals .24 in.
18 ft.	1.04 in.	1.04 in.	1.07 in.	1.05 in.	1.05 in.	1.01 in.	6.26 in. equals .26 in.
20 ft.	1.04 in.	1.04 in.	1.06 in.	1.06 in.	1.07 in.	1.03 in.	6.30 in. equals .30 in.

Contraction on Head.

15 ft.	.96 in.	.96 in.	.95 in.	.96 in.	.92 in.	.96 in.	5.71 in. equals .29 in.
18 ft.	.95 in.	.95 in.	.96 in.	.93 in.	.98 in.	.96 in.	5.73 in. equals .27 in.
20 ft.	.98 in.	.95 in.	.93 in.	.97 in.	.94 in.	.94 in.	5.71 in. equals .29 in.

MARYLAND STEEL CO.'S MILL—SPARROWS POINT, MD.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

October, 1910.

ANALYSIS.

Table 59—Melt, 2488.

Position.	Mn.	Si.	S.	P.	C.	Cr.	Ni.
Mill report..............	.69	.056	.033	.010	.73	.38	.55
A rail—1................	.67	....	.075	.020	.61	...	...
2................	.73	.037	.093	.023	.64	...	...
D rail—1................	.69	....	.060	.010	.66	...	...
2................	.73	.038	.060	.011	.67	...	...

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.04 in.	1.28 in.	1.74 in.
Permanent set, base..................	1.00 in.	1.22 in.	1.65 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.02 in.	1.02 in.	1.02 in.	1.05 in.	1.04 in.	1.02 in.	6.17 in. equals .17 in.
18 ft.	1.05 in.	1.04 in.	1.05 in.	1.05 in.	1.07 in.	1.03 in.	6.29 in. equals .29 in.
20 ft.	1.07 in.	1.05 in.	1.07 in.	1.05 in.	1.07 in.	1.03 in.	6.34 in. equals .34 in.

Contraction on Head.

15 ft.	.98 in.	.96 in.	.96 in.	.94 in.	.96 in.	.93 in.	5.73 in. equals .27 in.
18 ft.	.97 in.	.96 in.	.94 in.	.94 in.	.97 in.	.95 in.	5.73 in. equals .27 in.
20 ft.	.97 in.	.93 in.	.95 in.	.93 in.	.94 in.	.96 in.	5.68 in. equals .32 in.

ANALYSIS.

Table 60—Melt, 4203.

Position.	Mn.	Si.	S.	P.	C.	Cr.	Ni.
Mill report..............	.61	.050	.033	.010	.62	.25	.51
A rail—1................	.65	....	.049	.010	.62	...	...
2................	.65	.038	.063	.011	.63	...	...
D rail—1................	.60	....	.049	.010	.60	...	...
2................	.60	.039	.056	.010	.60	...	...

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.42 in.	1.68 in.	1.96 in.
Permanent set, base..................	1.38 in.	1.36 in.	1.83 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.02 in.	1.05 in.	1.03 in.	1.06 in.	1.05 in.	1.05 in.	6.26 in. equals .26 in.
18 ft.	1.05 in.	1.04 in.	1.07 in.	1.05 in.	1.08 in.	1.02 in.	6.31 in. equals .31 in.
20 ft.	1.05 in.	1.04 in.	1.05 in.	1.09 in.	1.08 in.	1.04 in.	6.35 in. equals .35 in.

Contraction on Head.

15 ft.	.98 in.	.96 in.	.95 in.	.95 in.	.97 in.	.93 in.	5.74 in. equals .26 in.
18 ft.	.97 in.	.96 in.	.94 in.	.93 in.	.97 in.	.93 in.	5.70 in. equals .30 in.
20 ft.	.97 in.	.94 in.	.93 in.	.92 in.	.96 in.	.91 in.	5.63 in. equals .37 in.

ANALYSIS.

Table 61—Melt, 2487.

Position.	Mn.	Si.	S.	P.	C.	Cr.	Ni.
Mill report..............	.64	.050	.037	.018	.65	.71	.50
A rail—1................	.65	....	.079	.017	.63	...	...
2................	.67	.037	.087	.023	.64	...	...
D rail—1................	.67	....	.049	.012	.64	...	...
2................	.67	.037	.051	.012	.64	...	...

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.06 in.	1.24 in.	1.80 in.
Permanent set, base..................	1.02 in.	1.22 in.	1.66 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.03 in.	1.04 in.	1.05 in.	1.07 in.	1.02 in.	6.25 in. equals .25 in.
18 ft.	1.07 in.	1.04 in.	1.06 in.	1.03 in.	1.06 in.	1.02 in.	6.28 in. equals .28 in.
20 ft.	1.04 in.	1.04 in.	1.07 in.	1.07 in.	1.08 in.	1.03 in.	6.33 in. equals .33 in.

Contraction on Head.

15 ft.	.98 in.	.96 in.	.92 in.	.97 in.	.95 in.	.95 in.	5.73 in. equals .27 in
18 ft.	.95 in.	.93 in.	.97 in.	.92 in.	.98 in.	.98 in.	5.73 in. equals .27 in.
20 ft.	.97 in.	.95 in.	.92 in.	.95 in.	.94 in.	.93 in.	5.66 in. equals .34 in.

MARYLAND STEEL CO.'S MILL—SPARROWS POINT, MD.

85-lb. A. S. C. E. Section Rail—O. H. Steel.

October, 1910.

ANALYSIS.

Table 62—Melt, 5228.

Position.	Mn.	Si.	S.	P.	C.	Cr.	Ni.
Mill report	.65	.052	.042	.022	.64	.40	.51
A rail—1	.62	....	.065	.017	.64	...	...
2	.67	.055	.079	.030	.73	...	...
D rail—1	.62	....	.059	.016	.64	...	...
2	.62	.047	.060	.016	.64	...	...

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.26 in.	1.43 in.	1.66 in.
Permanent set, base	1.19 in.	1.35 in.	1.51 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.04 in.	1.05 in.	1.05 in.	1.06 in.	1.02 in.	6.27 in. equals .27 in.
18 ft.	1.03 in.	1.05 in.	1.05 in.	1.06 in.	1.04 in.	1.06 in.	6.29 in. equals .29 in.
20 ft.	1.06 in.	1.04 in.	1.07 in.	1.06 in.	1.08 in.	1.02 in.	6.33 in. equals .33 in.

Contraction on Head.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	.96 in.	.94 in.	.95 in.	.94 in.	.97 in.	.97 in.	5.73 in. equals .27 in.
18 ft.	.98 in.	.91 in.	.97 in.	.96 in.	.94 in.	.96 in.	5.72 in. equals .28 in.
20 ft.	.96 in.	.95 in.	.92 in.	.95 in.	.95 in.	.95 in.	5.68 in. equals .32 in

ANALYSIS.

Table 63—Melt, 1508.

Position.	Mn.	Si.	S.	P.	C.	Cr.	Ni
Mill report	.78	.053	.048	.014	.63	.48	.44
A rail—1	.67	....	.057	.020	.61	...	...
2	.69	.038	.057	.019	.63	...	...
D rail—1	.67	....	.045	.014	.63	...	...
2	.67	.038	.059	.019	.64	...	...

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.10 in.	1.34 in.	1.46 in.
Permanent set, base	1.03 in.	1.28 in.	1.39 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.03 in.	1.04 in	1.05 in.	1.07 in.	1.02 in.	6.26 in. equals .26 in.
18 ft.	1.03 in.	1.05 in.	1.07 in.	1.03 in.	1.08 in.	1.02 in.	6.28 in. equals .28 in.
20 ft.	1.06 in.	1.05 in.	1.06 in.	1.05 in.	1.06 in.	1.03 in.	6.31 in. equals .31 in.

Contraction on Head.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	.97 in.	.95 in.	.94 in.	.97 in.	.97 in.	.96 in.	5.76 in. equals .24 in.
18 ft.	.97 in.	.95 in.	.93 in.	.97 in.	.94 in.	.96 in.	5.72 in. equals .28 in.
20 ft.	.96 in.	.93 in.	.93 in.	.95 in.	.96 in.	.97 in.	5.70 in. equals .30 in.

ANALYSIS.

Table 64—Melt, 5229.

Position.	Mn.	Si.	S.	P.	C.	Cr.	Ni.
Mill report	.63	.050	.037	.010	.65	.40	.52
A rail—1	.60	....	.051	.010	.63	...	...
2	.60	.038	.053	.010	.65	...	...
D rail—1	.62	....	.033	.010	.62	...	...
2	.62	.046	.045	.011	.64	...	...

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	broke	1.44 in.	1.60 in.
Permanent set, base	......	1.38 in.	1.49 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	....	....	....	....	....	....	broke
18 ft.	1.05 in.	1.03 in.	1.05 in.	1.06 in.	1.05 in.	1.03 in.	6.27 in. equals .27 in
20 ft.	1.03 in.	1.06 in.	1.05 in.	1.05 in.	1.07 in.	1.04 in.	6.30 in. equals .30 in.

Contraction on Head.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	......	......	......	......	......	......	broke
18 ft.	.95 in.	.95 in.	.94 in.	.98 in.	.95 in.	.93 in.	5.70 in. equals .30 in.
20 ft.	.98 in.	.98 in.	.95 in.	.93 in.	.98 in.	.93 in.	5.75 in. equals .25 in.

NOTES ON CHEMICAL ANALYSIS OF MARYLAND STEEL CO.'S OPEN-HEARTH RAIL—OCTOBER, 1910.

By

J. H. GIBBONEY, Chemist.

Melt 5228—This melt shows slight segregation in "A" rail. "D" rail normal and agrees very closely with mill results.

Melt 2487—This melt shows good agreement, for both "A" and "D" rails, with mill analysis. Higher Sulphur is found than the figure reported by mill.

Melt 1508—This melt shows good agreement, for both "A" and "D" rails, with mill analyses. No segregation.

Melt 4203—This melt shows good agreement. No segregation.

Melt 2488—This melt shows good agreement, except in Sulphur. No segregation.

Melt 3446—This melt shows good agreement, except as to Manganese, in "A" and "D" rail.

Melt 5229—This melt shows good agreement. No segregation.

ILLINOIS STEEL COMPANY—GARY MILL.

100-lb. A. R. A. Section, Type B.—O. H. Steel Rails.

November, 1910.

ANALYSIS.

Table 65—Melt, 55497.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.67	.170	.053	.035	.67
. 1	.73	....	.051	.032	.60
2	.73	.196	.048	.034	.63
1	.73	....	.047	.035	.65
2	.73	.159	.048	.035	.66

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.54 in.	1.33 in.	1.86 in.
Permanent set, base	1.45 in.	1.28 in.	1.76 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.02 in.	1.02 in.	1.03 in.	1.05 in.	1.05 in.	1.05 in.	6.22 in. equals .22 in.
18 ft.	1.03 in.	1.05 in.	1.03 in.	1.05 in.	1.03 in.	1.04 in.	6.23 in. equals .23 in.
20 ft.	1.04 in.	1.04 in.	1.05 in.	1.05 in.	1.05 in.	1.04 in.	6.27 in. equals .27 in.

Contraction on Head.

15 ft.	.97 in.	.97 in.	.95 in.	.95 in.	.96 in.	.95 in.	5.75 in. equals .25 in.
18 ft.	.97 in.	.96 in.	.96 in.	.97 in.	.93 in.	.95 in.	5.74 in. equals .26 in.
20 ft.	.97 in.	.92 in.	.93 in.	.97 in.	.90 in.	.93 in.	5.62 in. equals .38 in.

ILLINOIS STEEL COMPANY—GARY MILL.

100-lb. A. R. A. Section, Type B.—O. H. Steel Rails.

November, 1910.

ANALYSIS.

Table 66—Melt, 49520.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.64	.200	.051	.040	.62
1...............	.66	....	.051	.049	.60
2...............	.70	.194	.069	.055	.62
1...............	.65	....	.065	.055	.60
2...............	.68	.157	.067	.055	.62

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.36 in.	1.50 in.	1.62 in.
Permanent set, base..................	1.37 in.	1.40 in.	1.60 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.03 in.	1.04 in.	1.03 in.	1.05 in.	1.04 in.	6.22 in. equals .22 in
18 ft.	1.04 in.	1.03 in.	1.02 in.	1.05 in.	1.03 in.	1.04 in.	6.21 in. equals .21 in.
20 ft.	1.03 in.	1.03 in.	1.05 in.	1.06 in.	1.05 in.	1.05 in.	6.27 in. equals .27 in.

Contraction on Head.

15 ft.	.97 in.	.95 in.	.93 in.	.97 in.	.96 in.	.94 in.	5.72 in. equals .28 in.
18 ft.	.97 in.	.97 in.	.91 in.	.97 in.	.97 in.	.92 in.	5.71 in. equals .29 in.
20 ft.	.97 in.	.94 in.	.92 in.	.96 in.	.96 in.	.92 in.	5.67 in. equals .33 in.

ANALYSIS.

Table 67—Melt, 47489.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.70	.150	.037	.027	.69
1...............	.65	....	.045	.032	.62
2...............	.67	.185	.066	.045	.68
1...............	.68	....	.070	.051	.67
2...............	.68	.200	.072	.053	.67

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.38 in.	1.62 in.	1.91 in.
Permanent set, base..................	1.31 in.	1.53 in.	1.84 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.04 in.	1.03 in.	1.03 in.	1.07 in.	1.03 in.	6.25 in. equals .25 in.
18 ft.	1.08 in	1.03 in.	1.06 in.	1.04 in.	1.06 in.	1.04 in.	6.31 in. equals .31 in.
20 ft.	1.06 in.	1.04 in.	1.05 in.	1.06 in.	1.07 in.	1.04 in.	6.32 in. equals .32 in.

Contraction on Head.

15 ft.	.94 in.	.95 in.	.96 in.	.95 in.	.97 in.	.96 in.	5.73 in. equals .27 in.
18 ft.	.93 in.	.93 in.	.96 in.	.92 in.	.94 in.	.97 in.	5.65 in. equals .35 in.
20 ft.	.93 in.	.91 in.	.96 in.	.93 in.	.92 in.	.96 in.	5.61 in. equals .39 in.

ANALYSIS.

Table 68—Melt, 48474.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.66	.200	.044	.031	.62
1...............	.73	....	.049	.042	.66
2...............	.76	.168	.065	.047	.78
1...............	.73	....	.057	.040	.66
2...............	.72	.206	.054	.039	.66

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.34 in.	1.45 in.	1.70 in.
Permanent set, base..................	1.29 in.	1.40 in.	1.62 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.02 in.	1.05 in.	1.03 in.	1.04 in.	1.04 in.	6.22 in. equals .22 in.
18 ft.	1.05 in.	1.03 in.	1.04 in.	1.03 in.	1.06 in.	1.03 in.	6.24 in. equals .24 in.
20 ft.	1.04 in.	1.04 in.	1.05 in.	1.06 in.	1.04 in.	1.06 in.	6.29 in. equals .29 in.

Contraction on Head.

15 ft.	.96 in.	.94 in.	.98 in.	.93 in.	.95 in.	.98 in.	5.74 in. equals .26 in.
18 ft.	.96 in.	.95 in.	.97 in.	.92 in.	.96 in.	.97 in.	5.73 in. equals .27 in.
20 ft.	.96 in.	.93 in.	.92 in.	.97 in.	.92 in.	.94 in.	5.64 in. equals .36 in.

ILLINOIS STEEL COMPANY—GARY MILL.

100-lb. A. R. A. Section, Type B.—O. H. Steel Rails.

November, 1910.

ANALYSIS.

Table 69—Melt, 48473.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.57	.160	.036	.020	.66
1...............	.65	....	.051	.050	.62
2...............	.73	.147	.087	.078	.76
1...............	.55	....	.049	.034	.68
2...............	.56	.110	.049	.035	.68

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.24 in.	1.45 in.	1.84 in.
Permanent set, base..................	1.18 in.	1.40 in.	1.88 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.02 in.	1.03 in.	1.03 in.	1.05 in.	1.03 in.	6.19 in. equals .19 in.
18 ft.	1.04 in.	1.05 in.	1.05 in.	1.03 in.	1.05 in.	1.05 in.	6.27 in. equals .27 in.
20 ft.	1.04 in.	1.06 in.	1.05 in.	1.06 in.	1.06 in.	1.07 in.	6.34 in. equals .34 in.

Contraction on Head.

15 ft.	.98 in.	.96 in.	.96 in.	.95 in.	.95 in.	.97 in.	5.77 in. equals .23 in.
18 ft.	.95 in.	.92 in.	.97 in.	.95 in.	.93 in.	.98 in.	5.70 in. equals .30 in.
20 ft.	.96 in.	.95 in.	.90 in.	.95 in.	.94 in.	.93 in.	5.63 in. equals .37 in.

ANALYSIS.

Table 70—Melt, 52505.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.68	.180	.033	.029	.70
1...............	.73	....	.039	.034	.68
2...............	.73	.121	.036	.034	.72
1...............	.73	....	.047	.033	.70
2...............	.73	.149	.047	.033	.69

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.22 in.	1.40 in.	1.82 in.
Permanent set, base..................	1.16 in.	1.34 in.	1.70 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.05 in.	1.02 in.	1.06 in.	1.03 in.	1.05 in.	1.03 in.	6.24 in. equals .24 in.
18 ft.	1.04 in.	1.05 in.	1.04 in.	1.04 in.	1.03 in.	1.05 in.	6.25 in. equals .25 in.
20 ft.	1.03 in.	1.06 in.	1.04 in.	1.05 in.	1.04 in.	1.06 in.	6.28 in. equals .28 in.

Contraction on Head.

15 ft.	.98 in.	.92 in.	.96 in.	.93 in.	.96 in.	.97 in.	5.72 in. equals .28 in.
18 ft.	.96 in.	.92 in.	.93 in.	.97 in.	.92 in.	.97 in.	5.67 in. equals .33 in.
20 ft.	.95 in.	.92 in.	.95 in.	.96 in.	.90 in.	.96 in.	5.64 in. equals .36 in.

ANALYSIS.

Table 71—Melt, 45526.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.67	.200	.043	.033	.70
1...............	.72	....	.047	.043	.68
2...............	.77	.168	.077	.072	.92
1...............	.57	....	.039	.034	.62
2...............	.62	.102	.045	.035	.66

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.12 in.	1.38 in.	1.71 in.
Permanent set, base..................	1.12 in.	1.30 in.	1.64 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.02 in.	1.04 in.	1.03 in.	1.03 in.	1.04 in.	6.20 in. equals .20 in.
18 ft.	1.04 in.	1.03 in.	1.05 in.	1.04 in.	1.03 in.	1.02 in.	6.21 in. equals .21 in.
20 ft.	1.02 in.	1.06 in.	1.06 in.	1.06 in.	1.03 in.	1.02 in.	6.25 in. equals .25 in.

Contraction on Head.

15 ft.	.98 in.	.93 in.	.97 in.	.96 in.	.94 in.	.96 in.	5.74 in. equals .26 in.
18 ft.	.97 in.	.97 in.	.91 in.	.98 in.	.96 in.	.97 in.	5.76 in. equals .24 in.
20 ft.	.94 in.	.93 in.	.97 in.	.92 in.	.95 in.	.97 in.	5.68 in. equals .32 in.

ILLINOIS STEEL COMPANY—GARY MILL.

100-lb. A. R. A. Section, Type B.—O. H. Steel Rails.

November, 1910.

ANALYSIS.

Table 72—Melt, 54499.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.80	.200	.046	.040	.73
1	.80	....	.051	.045	.68
2	.85	.243	.067	.052	.72
1	.83	....	.057	.050	.72
2	.82	.196	.069	.054	.72

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.10 in.	1.20 in.	1.42 in.
Permanent set, base	1.06 in.	1.15 in.	1.42 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.02 in.	1.04 in.	1.04 in.	1.05 in.	1.03 in.	6.21 in. equals .21 in.
18 ft.	1.02 in.	1.04 in.	1.03 in.	1.03 in.	1.03 in.	1.04 in.	6.19 in. equals .19 in.
20 ft.	1.04 in.	1.06 in.	1.05 in.	1.05 in.	1.02 in.	1.05 in.	6.27 in. equals .27 in.

Contraction on Head.

15 ft.	.96 in.	.94 in.	.96 in.	.96 in.	.96 in.	.98 in.	5.76 in. equals .24 in.
18 ft.	.98 in.	.97 in.	.95 in.	.95 in.	.94 in.	.98 in.	5.77 in. equals .23 in.
20 ft.	.96 in.	.95 in.	.95 in.	.95 in.	.92 in.	.95 in.	5.68 in. equals .32 in.

ANALYSIS.

Table 73—Melt, 33237.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.75	.150	.046	.020	.71
1	.80	....	.047	.028	.70
2	.85	.140	.107	.046	1.04
1	.78	....	.059	.024	.68
2	.78	.121	.067	.029	.72

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.30 in.	1.39 in.	1.54 in.
Permanent set, base	1.21 in.	1.35 in.	1.45 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.04 in.	1.04 in.	1.04 in.	1.03 in.	1.02 in.	1.03 in.	6.20 in. equals .20 in.
18 ft.	1.02 in.	1.04 in.	1.05 in.	1.06 in.	1.06 in.	1.06 in.	6.29 in. equals .29 in.
20 ft.	1.03 in.	1.03 in.	1.06 in.	1.05 in.	1.05 in.	1.04 in.	6.26 in. equals .26 in.

Contraction on Head.

15 ft.	.96 in.	.91 in.	.98 in.	.97 in.	.94 in.	.98 in.	5.74 in. equals .26 in.
18 ft.	.95 in.	.95 in.	.93 in.	.98 in.	.94 in.	.93 in.	5.68 in. equals .32 in.
20 ft.	.95 in.	.92 in.	.96 in.	.95 in.	.92 in.	.94 in.	5.64 in. equals .36 in.

ANALYSIS.

Table 74—Melt, 53504.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report	.68	.160	.047	.040	.62
1	.65	....	.043	.032	.70
2	.71	.176	.055	.040	.76
1	.68	....	.069	.054	.64
2	.70	.157	.067	.054	.64

DROP TEST

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head	1.03 in.	1.24 in.	1.68 in.
Permanent set, base	1.04 in.	1.18 in.	1.58 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.02 in.	1.05 in.	1.04 in.	1.04 in.	1.02 in.	1.02 in.	6.19 in. equals .19 in.
18 ft.	1.01 in.	1.03 in.	1.07 in.	1.04 in.	1.03 in.	1.05 in.	6.23 in. equals .23 in.
20 ft.	1.03 in.	1.03 in.	1.08 in.	1.03 in.	1.05 in.	1.06 in.	6.28 in. equals .28 in.

Contraction on Head.

15 ft.	.93 in.	.98 in.	.95 in.	.95 in.	.97 in.	.98 in.	5.76 in. equals .24 in.
18 ft.	.96 in.	.96 in.	.92 in.	.97 in.	.96 in.	.93 in.	5.70 in. equals .30 in.
20 ft.	.98 in.	.96 in.	.93 in.	.92 in.	.98 in.	96 in.	5.73 in. equals .27 in.

ILLINOIS STEEL COMPANY—GARY MILL.

100-lb. A. R. A. Section, Type B.—O. H. Steel Rails.

November, 1910.

ANALYSIS.

Table 75—Melt, 43481.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.62	.170	.038	.022	.66
1..............	.62	....	.061	.040	.70
2..............	.62	.168	.065	.040	.70
1..............	.63	....	.047	.037	.66
2..............	.65	.140	.047	.037	.66

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.22 in.	1.50 in.	1.56 in.
Permanent set, base..................	1.17 in.	1.42 in.	1.68 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.05 in.	1.04 in.	1.04 in.	1.03 in.	1.03 in.	6.22 in. equals .22 in.
18 ft.	1.04 in.	1.05 in.	1.04 in.	1.04 in.	1.05 in.	1.06 in.	6.28 in. equals .28 in.
20 ft.	1.03 in.	1.05 in.	1.06 in.	1.05 in.	1.05 in.	1.03 in.	6.27 in. equals .27 in.

Contraction on Head.

15 ft.	.98 in.	.93 in.	.98 in.	.94 in.	.94 in.	.98 in.	5.75 in. equals .25 in.
18 ft.	.97 in.	.92 in.	.95 in.	.97 in.	.95 in.	.96 in.	5.72 in. equals .28 in.
20 ft.	.96 in.	.94 in.	.91 in.	.96 in.	.94 in.	.94 in.	5.65 in. equals .35 in.

ANALYSIS.

Table 76—Melt, 46523.

Position.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Carbon.
Mill report...........	.70	.200	.048	.040	.68
1..............	.73	....	.063	.053	.72
2..............	.73	.140	.085	.064	.72
1..............	.73	....	.061	.048	.68
2..............	.74	.140	.069	.048	.68

DROP TEST.

	15 ft. Drop.	18 ft. Drop.	20 ft. Drop.
Permanent set, head..................	1.25 in.	1.30 in.	2.02 in.
Permanent set, base..................	1.22 in.	1.24 in.	1.94 in.

Elongation on Base.

Drop.	1st in.	2d in.	3d in.	4th in.	5th in.	6th in.	Total in 6 in.
15 ft.	1.03 in.	1.04 in.	1.04 in.	1.02 in.	1.04 in.	1.03 in.	6.20 in equals .20 in.
18 ft.	1.02 in.	1.05 in.	1.04 in.	1.04 in.	1.06 in.	1.04 in.	6.25 in. equals .25 in.
20 ft.	1.02 in.	1.04 in.	1.07 in.	1.06 in.	1.07 in.	1.06 in.	6.32 in. equals .32 in.

Contraction on Head.

15 ft.	.96 in.	.92 in.	.97 in.	.95 in.	.97 in.	.98 in.	5.75 in. equals .25 in.
18 ft.	.98 in.	.96 in.	.92 in.	.98 in.	.94 in.	.97 in.	5.75 in. equals .25 in.
20 ft.	.96 in.	.94 in.	.91 in.	.93 in.	.94 in.	.93 in.	5.61 in. equals .39 in.

NOTES ON CHEMICAL ANALYSIS.

By

J. H. Gibboney, Chemist.

Melt 47489—The Sulphur and Phosphorus, as determined, show slightly higher results.

Melt 49520—This melt shows very good agreement, our Phosphorus being slightly higher.

Melt 48473—Segregation noted in "A" rail.

Melt 53504—Very good agreement, with slightly higher Carbons.

Melt 43481—Very good agreement, except for higher Sulphur and Phosphorus.

Melt 54499—Very good agreement.

Melt 48474—Slightly higher results found in all ingredients.

Melt 45526—Segregation noted in "A" rail. Very good agreement in "D" rail.

Melt 33237—Segregation noted in "A" rail. Very good agreement in "D" rail.

Melt 46523—Slight segregation noted in the "A" rail in Sulphur and Phosphorus, otherwise very good agreement.

Melt 52505—Very good agreement.

Melt 55497—Very good agreement.

Taken as a whole this rolling shows up very well, with the exception of Melts 45526 and 33237, which showed considerable segregation in the "A" rail. All Carbons by color. N. & W. Standard method of drilling sections for analyses followed, as per Fig. 1. Segregation is noted in Melt 48473, but the Carbon did not make as great a jump as noted in Melts 45526 and 33237.

CARBON AND DEFLECTION OF RAILS IN DROP TEST

By M. H. Wickhorst, Engineer of Tests, Rail Committee.

This report covers a study of the influence of carbon on the deflection of a rail in the drop test and is based on the results of the drop tests given by C. S. Churchill in Report No. 14 to the Rail Committee, and which were made for him by J. A. Colby. These tests were made on 85-lb. open-hearth rails of the A. S. C. E. section, with a nominal moment of inertia of 30.0, except those on the Gary rails, which were 100-lb. A R A section type B. Briefly, it will be recalled that three drop tests were made from each heat selected, one each at heights of 15 ft., 18 ft. and 20 ft., in the standard rail drop machines with a tup of 2,000 lbs. spring supported anvil of 10 tons and span of supports 3 ft. The pieces were from different rail bars and in general from the crop end just above the A rail. From the piece used for the 15-ft. drop, a small piece was cut and sent to J. H. Gibboney, Chemist Norfolk & Western Railway, Roanoke, Va., for special analysis. From each piece two samples were analyzed, one from the outer corners of the head and the other from the interior of the head, as shown in the diagram in Report No. 14. For this study the permanent deflection at 15 ft. was used and the analysis by Gibboney was used of the sample representing the outer part of the section of the rail as the outer fibers have more influence on the deflection than the interior ones. Only those results were used where the outer and the interior samples show about the same composition.

The number of results at 15 ft. shown in Mr. Churchill's report, the makers represented and the number of results used for this study, are as follows:

Maker.	Total results at 15 ft.	Results used for this report
Carnegie Steel Co.	15	12
Pennsylvania Steel Co.	15	none
Tenn. Coal, Iron & R. R. Co.	12	12
Bethlehem Steel Co.	15	15
Maryland Steel Co.	7	none
Ill. Steel Co.—Gary Works...............	12	none

Report No. 15, February, 1911.

Of the 15 results of Carnegie rails, three were discarded on account of differences in chemical results between the outer and interior samples. Of the 15 Pennsylvania results, 11 were discarded for the same reason, and as the four remaining results were too few, the tests of rails from this mill were not available for the present study. The tests at the Maryland Steel Co. were made on rails containing chromium and nickel, and were too few to be considered in this study. Of the 12 Gary results 8 were discarded because of lack of agreement between the outer and inner portions of the section, and the four remaining were too few to be used.

The results used are shown in tables 1, 2 and 3.

TABLE 1—CARNEGIE STEEL CO.

Table No.	Melt.	C.	P.	Mn.	Defl. 15-ft. base.
12	32,341	.65	.012	.57	1.39
1	35,218	.65	.017	.59	1.40
7	44,221	.67	.014	.64	1.31
3	43,297	.67	.029	.63	1.34
8	33,212	.69	.012	.67	1.32
2	32,244	.70	.032	.61	1.33
6	34,227	.72	.027	.72	1.24
4	33,363	.72	.040	.62	1.35
9	45,328	.74	.026	.64	1.30
5	33,219	.75	.010	.60	1.35
10	36,223	.75	.037	.57	1.34
15	39,222	.76	.020	.82	1.25
Average		.706	.023	.64	1.327

TABLE 2—TENN. C., I. & R. R. CO.

Table No.	Melt.	C.	P.	Mn.	Defl. 15-ft. base.
40	60,464	.59	.022	.66	1.71
37	40,485	.61	.029	.62	1.60
31	10,471	.62	.025	.74	1.56
35	50,464	.63	.032	.67	1.60
33	40,484	.63	.033	.70	1.30
32	60,463	.64	.032	.63	1.68
38	50,463	.64	.035	.60	1.83
41	10,472	.65	.020	.70	1.66
34	50,462	.67	.045	.69	1.50
42	20,449	.69	.018	.69	1.50
36	10.470	.69	.028	.68	1.46
39	60,465	.69	.029	.67	1.44
Average		.646	.029	.67	1.570

TABLE 3—BETHLEHEM STEEL CO.

Table No.	Melt.	C.	P.	Mn.	Defl. 15-ft. base.
56	B-16,468	.60	.022	.68	1.50
47	P-2,246	.62	.030	.63	1.38
51	B-16,470	.66	.018	.67	1.36
44	B-16,472	.68	.023	.69	1.23
57	L-2,048	.68	.030	.82	1.19
52	E-971	.68	.031	.72	1.26
55	B-16,469	.70	.021	.75	1.20
43	B-20,428	.70	.023	.61	1.48
46	B-19,383	.72	.023	.79	1.22
49	E-972	.72	.032	.79	1.18
50	B-21,437	.73	.017	.82	1.14
53	B-17,548	.74	.018	.78	1.12
48	B-17,549	.74	.022	.81	1.22
54	B-20,426	.74	.023	.80	1.16
45	B-20,427	.88	.023	.93	.97
Average		.706	.024	.75	1.241

The element having the most influence on the deflection is, of course, the carbon, and judging from our knowledge of the influence of the elements on the tensile properties, it is probable that phosphorus exerts an influence and perhaps manganese does also. Sulphur need not be considered and probably silicon has only a minor influence, if any, in the quantities that exist in rail steel. At any rate it cannot be considered in a preliminary investigation. In order to show up concisely what relationships may exist between carbon and deflection in the various lots of rail tested, I have plotted in Fig. 1, the carbon-deflection diagrams for the Carnegie, Tennessee and Bethlehem rails, showing the per cent. of carbon horizontally and vertically the permanent deflection of the base side of the rail under a 15-ft. drop. The deflection of the head side was not used on account of the local indentation caused by the tup and it was thought better to eliminate this feature in the present study. In order to more readily and accurately locate the curves fitting the plotted points, those points representing about the same carbon but lying at opposite sides of the "band" of points, were averaged as indicated by the connecting lines and the average value is shown by a small circle. In most cases the average is that of two points, in some cases of three points, and in some other cases the points were left single. In drawing the deflection curves, the "average" points or "centers of gravity" were given a weight according to the number of single points they represent. A few points that fell entirely out of their "zone" were ignored in drawing the curves. The curves are represented as straight lines and no attempt at closer fitting has been made, as with the small amount of data in hand and their small range, there must be considerable doubt as to even the slope of the line, let alone its curvature.

Referring to Fig. 1, it will be noted that the slopes of the deflection lines of the Tennessee and Bethlehem rails are about the same, but the deflection of the Tennessee rails is over .2 in. more than that of the Bethlehem rails; at .70 per cent. carbon the Bethlehem rails showing about 1.23 in. and the Tennessee rails about 1.44 in. deflection. There seems not to be sufficient information at hand to explain the difference, but among possibilities may be mentioned, a slight difference in the sections may have existed, which would change the moment of inertia, or the spans of the supports may not have been strictly alike in both cases, or the anvils or tups or heights of drop may have been somewhat different, or again difference in temperature of rolling may have produced the difference in deflection, or it may be due to some difference in other elements besides carbon. The deflection line of the Carnegie rails comes in between the other two, but its slope is very much less. The number of points is small and although the line probably fits the points actually in hand as well as possible, it might readily be changed by more accurate or more extensive information.

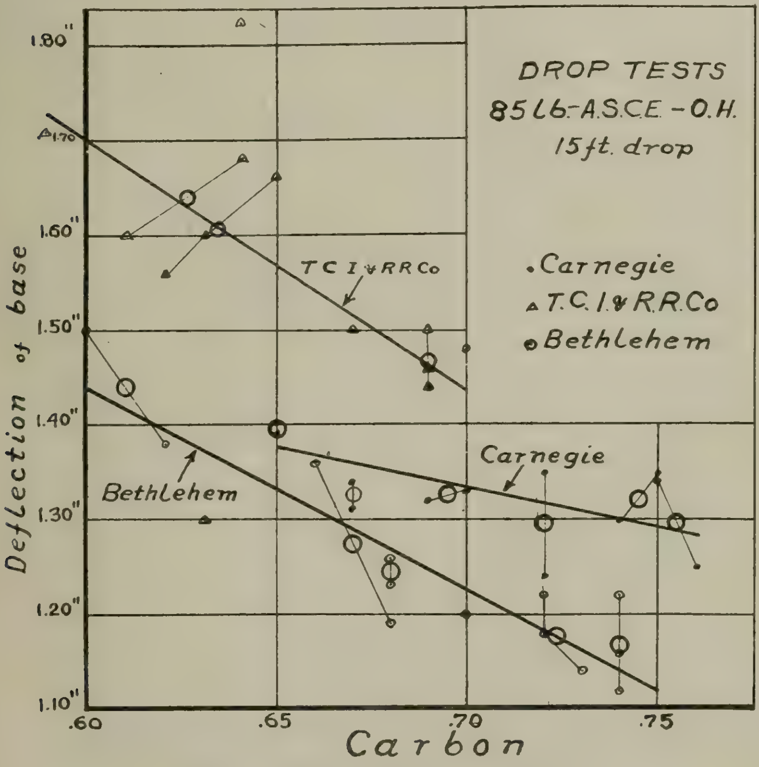

FIG 1. CARBON-DEFLECTION CURVES.

Of course the deflection lines discussed above represent the combined effect of all the stiffening elements, although the slope would be due to carbon providing the other stiffening elements were constant. In order to study the possible influence of the phosphorus on the slope of the line I show in Fig. 2 the carbon-phosphorus diagrams with the carbon plotted horizontally and the phosphorus vertically. Of course these diagrams have no general significance and are given simply to note whether the phosphorus variations happen to have any relation to the carbon variations. It will be noted that in the Carnegie and Tennessee rails the phosphorus at first has an upward trend as the carbon increases but toward the end tends to drop again, and the average differences are probably too small to have any noticeable influence on the carbon-deflection curves. The phosphorus in the Bethlehem rails shows no relation to the carbon content. It may be said, therefore, that in general the phosphorus variations have had no influence on the slope of the carbon-deflection lines shown in Fig. 1.

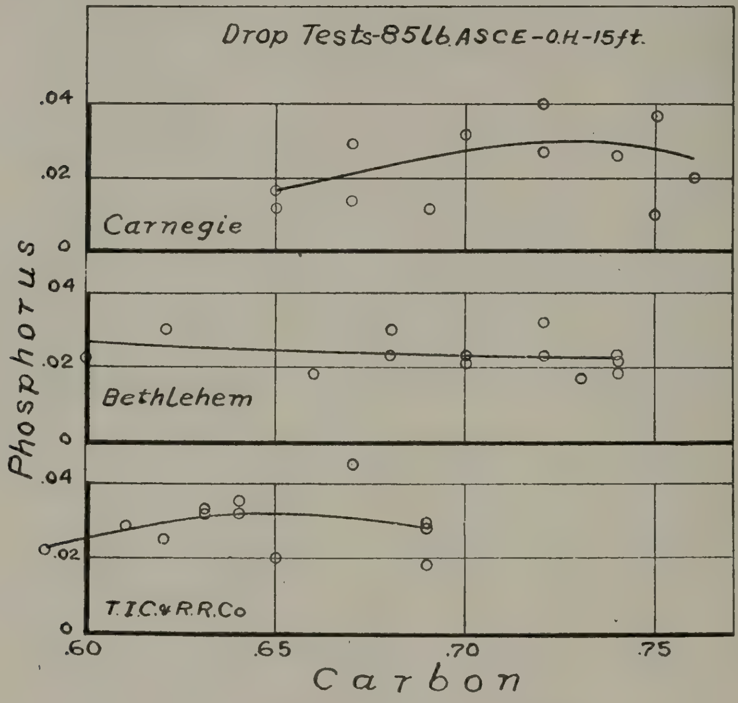

FIG. 2. CARBON-PHOSPHORUS DIAGRAMS.

The carbon-manganese diagrams are similarly shown in Fig. 3 and it seems probable that in the Carnegie and Tennessee rails that manganese has had no material influence on the slope of carbon-deflection curve.

In the case of the Bethlehem rails, however, the general increase in manganese is about equal to that of the carbon and the slope of the carbon-deflection curve would be a result of the combined effect of about equal amounts of carbon and manganese above the starting point of .60 per cent. carbon. If manganese has a marked stiffening effect it should show in a very steep slope in the deflection curves of the Bethlehem rails, while the slope is not quite as steep as with the Tennessee rails.

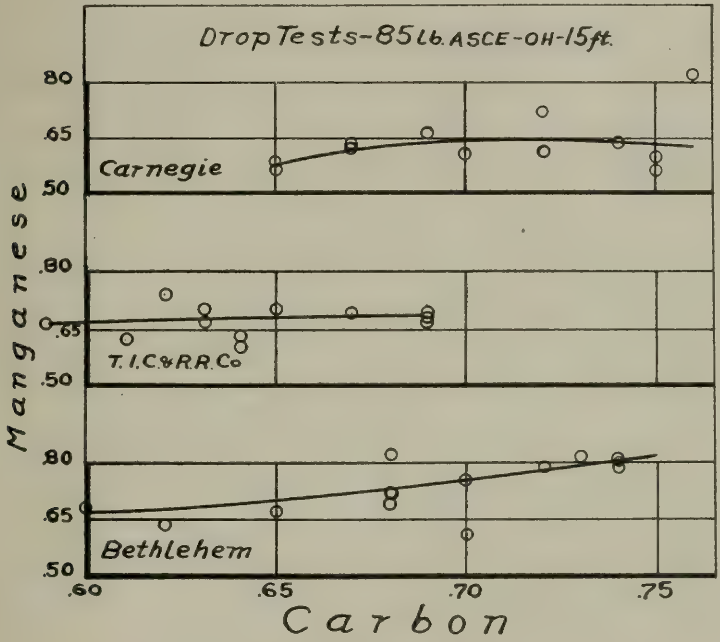

FIG. 3. CARBON-MANGANESE DIAGRAMS.

The influence which the carbon has on the deflection as indicated on the carbon-deflection curves of Fig. 1 is summarized numerically in table 4.

TABLE 4—DEFELCTION AS INFLUENCED BY CARBON.

	Carnegie.	Tennessee.	Bethlehem.
Deflection at .60% Carbon	....	1.70″	1.44″
Deflection at .65% Carbon	1.38″	....	....
Deflection at .70% Carbon	....	1.44″	....
Deflection at .75% Carbon	1.29″	....	1.12″
Difference	.09″	.26″	.32″
Average change with .01% carbon	.009″	.026″	.021″

It will be noted that within a carbon range from about .60 per cent. to about .75 per cent. the stiffening effect in these tests of a change .01 per cent. carbon was about .009 in. for the Carnegie rails, about .026 in. for the Tennessee rails, and about .021 in. for the Bethlehem rails, all being 85-lb. rails of A. S. C. E. section, with a nominal moment of inertia of 30.0. As explained above, the phosphorus and manganese remained in general about constant in the Carnegie and Tennessee rails, but in the Bethlehem rails, although the phosphorus averaged about constant, the carbon change was accompanied by a like change of manganese and of a like amount. The data at hand do not allow, however, of determining the distribution of effect between carbon and manganese.

Very roughly, then, this investigation indicates that above .60 per cent. each .01 per cent. carbon increase causes a decrease of deflection of base side of about .02 in. on 85-lb. O. H. rails of A. S. C. E. section when tested in the standard rail drop machine with tup of 2,000 lbs., span 3 ft. and height of drop of 15 ft.

The average deflection in these tests for .70 per cent. carbon was about 1.35 in. For carbon limits of .62 to .75 per cent., which are the ones usual in specifications for open-hearth steel rails, the range of deflection due to carbon alone, these tests indicate to be about ¼ in. It will be noted that, although the Tennessee and Bethlehem rails were nominally the same section and composition, differences existed in either the section, material or testing, or in two or all of these matters to make differences in deflection for the same carbon and about the same phosphorus and manganese almost as great as the whole range of carbon allowable in the same rolling.

DEFLECTION FORMULA.

The above study gives us some idea of the quantitative effect of carbon on the deflection of a rail in the drop test, but offers no information as to the effect of other elements. It would seem desirable, however, to know the exact quantitative effect of each factor having an influence on the deflection, so the information could be summarized in one or more formulas, and it is hoped that experimental work may be continued with this end in view, particularly since such information would seem very desirable for use of the sub-committee dealing with specifications.

In this connection I wish to offer some thoughts as to the form the formula should take. Starting with soft iron without any hardening elements the deflection under a given height of drop would be decreased with each increment of hardening material. It would be increased with an increase in the height of drop and decreased with an increase of the moment of inertia of the section and, perhaps, temperature of rolling should also be taken into account. The formula for deflection would then take the following form:

$$d = (K - cC - pP - mMn)\frac{h}{I}$$

where
d = deflection
K = constant for soft iron
C = carbon
c = constant for carbon
P = phosphorus
p = constant for phosphorus
Mn = manganese
m = constant for manganese
h = height of drop
I = moment of inertia

It is readily possible or even probable that the constants would change with different classes of steel, but the above form of the formula would probably be suitable for all of them, except we may find that the manganese factor may be omitted and possibly also the phosphorus in special cases, and again as stated temperature of rolling may have to be reckoned with. In experimental work done for the purpose of developing such a formula, specially accurate determinations should be made of each of the factors entering into it, including measurements of the section of each piece tested, so as to determine its actual geometrical moment of inertia, which is apt to be overlooked, and material for test should be selected having wide ranges in the various factors.

The Rail Committee hopes to carry this work farther and invites suggestions from engineers, metallurgists and others who may be interested in this work.

Appendix D.

A STUDY OF FORTY FAILED RAILS

By W. C. Cushing, Chief Engineer Maintenance of Way,
Pennsylvania Lines West of Pittsburgh, Southwest System, Pittsburgh, Pa.

With discussion by

M. H. Wickhorst, Engineer of Tests, Rail Committee.

This report covers a study of forty rails which failed in the main tracks on the Southwest System of the Pennsylvania Lines West of Pittsburgh, during the year 1909. The detail reports of the individual rails cover in most cases the following:

1. A statement of track conditions.
2. General photographs of the failure.
3. Photograph of the etched section.
4. Microphotograph in some cases.
5. Chemical analysis, from interior of head.
6. Physical test, from interior of head.

The laboratory examinations were made by R. W. Hunt & Co.

Mr. Cushing presented his file to the Committee on Rail, together with a tabulated statement of the main results and a discussion of them, dated February, 1910. The file was then edited for publication as this report by M. H. Wickhorst, who also presents some discussion.

Table 1 is a summary of the failures classified as "broken rails," and Table 2 is a summary of those classified as "crushed and split heads."

DISCUSSION BY CUSHING.

BROKEN RAILS.

(1) Sixteen broken rails of A. S. C. E., P. S. and P. R. R. sections were examined, and thirteen out of the sixteen were broken in or at the splices.

(2) Of the thirteen cases of failures in the splice, two (Nos. 5 and 7) were Weber joints, one (No. 8) Bonzano, and ten six-hole splice bar, which was standard at the time the rail was laid.

(3) Eight of these rails were considerably worn in the splicing space. but the metal of five of them was hard and brittle, and in some cases the constituents considerably segregated.

Report No. 12, January, 1911.

TABLE 1.—"BROKEN" RAILS.

No.	Sec No.	Weight of Rail lbs per Yard	Rail Section	Manufacturer	Year of Rolling	Bessemer or Open Hearth	Position in Ingot	Kind of Failures	Chemical Analysis					Physical Test				Fracture	Cause of Failure	No.
									C.	Mn	P	Si.	S.	Tensile Strength	Elastic Limit	Elongation per cent	Reduction of Area per cent of original section			
														lbs per sq inch.		in 2 ins				
1	49	85	A.S.C.E	Car.	1906	B		Broken	.584	1.17	.102	.110		122440	69430	17.0	27.15	Granular	Split from lap in base due to rolling.	1
2	29	"	"	"	1907	"		"	.487	1.14	.100	.113		113390	67130	19.0	33.79	S Gran	Lap in base from rolling	2
3	4	"	P.S	Ill.	1909	"	A	"	.596	1.03	.106	.143		114210	72240	3.50	0.0	Gran	Brittle in splice	3
4	48	"	"	"	1909	"	A	"	.771	.98	.154	.176	.078	87470	75970	1.00	0.0	Cryst	Brittle and segregated in splice.	4
5	1	100	A.S.C.E	Car.	1907	"		"	.578	.64	.126	.068		104230	66580	5.00	6.26	Gran	Brittle, unsound and segregated. In splice	5
6	16	"	"	"	1907	"		"	.618	1.60	.081	.156		141400	98450	11.50	14.75	Cryst	Somewhat hard and segregated	6
7	4	"	"	"	1906	"		"	.644	1.03	.112	.100		107460	79750	2.00	2.81	Gran	Hard and brittle Crack started by driving in bond plug	7
8	2.A.	"	"	"	1902	"		"	.509	.81	.099	.065		106320	72640	3.00	3.56	Cryst	Brittle, somewhat unsound and worn. In splicing space	8
9	42	85	P.R.R.	Ill.	1895	"		"	.490	.93	.096	.204		110210	80080	18.00	30.23	Gran.	Corrosion of flange. At splice	9
10	25	100	A.S.C.E	Car.	1906	"		"	.541	1.06	.085	.120		115750	92590	18.00	10.53	"	Flange worn thin. In splice	10
11	25	"	"	"	1906	"		"	.576	1.26	.081	.129		125200	74280	14.50	24.03	"	Quite hard and of diminished section About 83lbs. per yard	11
12	1	"	"	"	1906	"		"	.566	1.10	.085	.091		125560	83950	14.50	19.78	"	Considerably worn in splicing space. In splice.	12
13	25	"	"	"	1906	"		"	.622	1.11	.090	.096		100920	100920	4.00	3.15	Cryst	Hard, brittle and considerably worn in splicing space. In splice.	13
14	25	"	"	"	1906	"		"	.529	1.08	.086	.126		117370	66230	17.0	31.07	Gran.	Unknown. At Splice.	14
15	35	85	P.S	Ill.	1909	"	C	"	.544	.96	.092	.183		114930	69380	17.50	29.19	"	Unknown, Probably unusual strains. In Splice.	15
16	57	100	"	Car.	1909	O.H. "A"		"	.825	.68	.032	.109		116260	99230	24.00	28.83	"	Unknown. Probably unusual strains. In Splice.	16.

TABLE 2.—CRUSHED AND SPLIT HEADS.

No.	Sec. No.	Weight of Rail lbs. per Yard	Rail Section	Manufacturer	Year of Rolling	Bessemer or Open Hearth	Position in Ingot.	Kind of Failures	Chemical Analysis					Physical Test					Cause of Failure	No.
									C.	Mn.	P.	Si.	S.	Tensile Strength lbs. per sq. inch	Elastic Limit lbs. per sq. inch	Elongation per cent in 2 ins.	Reduction of Area per cent of original section	Fracture		
17	42	85	P.R.R.	Car.	1896	B		Crushed Head	.549	.74	.111	.065		112230	90320	21.00	18.23	Gran.	Unsound. Upper part of ingot.	17
18	56	"	A.S.C.E.	"	1905	"		" "	.643	1.04	.098	.094	.054						Hard and unsound.	18
19	50	"	"	"	1906	"		" "	.598	.88	.072	.109	.042	124180	76120	8.50	9.25	Gran.	Unwelded seam. unsound	19
20	35	100	"	"	1906	"		" "	.571	.99	.127	.094		98050	66940	3.50	0.0	"	Unsound and segregated. Upper part of ingot.	20
21	5	"	"	"	1907	"		" "	.580 .607 .641	.60	.052	.063	.044						Unsound and segregated Upper part of ingot.	21
22	3	85	P.S.	Ill.	1909	"	A.	" "	.578	.89	.128	.072		110630	76690	5.00	4.75	Gran.	Unsound and segregated.	22
23	42	85	P.S.	Gary	1909	O.H. "A"	C.	Flow of Metal	.735	.70	.025	.119		122020	72380	13.50	20.17	Gran.	Tie plate rolled in and caused split.	23
24	35	85	P.S.	Gary	1909	O.H. "A"		Split Head	.680	.740	.027	.120		110580	70140	5.00	0.00	Gran.	Tie plate rolled in and caused split.	24
25	35	"	"	"	1909	"		" "	.681	.77	.025	.080		118800	89610	15.00	20.06	"	" " " " " " "	25
26	13	"	"	Car.	1909	B.	E.	" "	.771	1.00	.133	.082		72490	72490	0.00	0.00	"	Hard, brittle and unsound	26
27	13	"	"	"	1909	"	G.	" "	.841	1.09	.168	.052		96990	96990	1.00	1.98	"	" " " "	27
28	18	"	"	"	1909	"	A.	" "	.788	.76	.149	.092	.078						Hard and unsound	28
29	18	"	"	"	1909	"	G.	" "	.714	.85	.210	.077	.104	124640	86450	2.00	1.20	Gran.	Hard, brittle and unsound.	29
30	101	"	"	"	1909	"	C.	" "	.807	.96	.140	.087	.059	90200	74200	1.00	1.48	"	" " " "	30
31	101	"	"	"	1909	"	C.	" "	.734	.93	.138	.089	.086	109700	74500	2.00	1.94	"	" " " "	31
32	31	100	"	"	1909	"	B.	" "	.616	.80	.095 .109 .120 .140	.129	.053	114770	63560	11.50	13.55	"	Segregated and unsound.	32
33	101	85	"	"	1909	"	C.	" "	.683	1.12	.122	.079		88550	88550	1.00	1.22	Cryst.	Hard, brittle and unsound.	33
34	9	100	A.R.A.-A.	"	1909	"		" "	.762 .789 .713	1.02	.145	.063		114880	66460	10.0	10.94	Gran.	Segregated and unsound.	34
35	9	"	"	"	1909	"	B.	" "	.637	.92	.118	.063		117040	85680	3.50	3.18	"	Brittle, unsound and segregated.	35
36	9	"	"	"	1909	"	B.	" "	.547	.98	.108	.065		102970	75000	2.50	0.00	Cryst.	Brittle and unsound.	36
37	43	85	P.R.R.	"	1895	"		" "	.537	.86	.170	.080		114210	60020	14.50	22.23	Gran.	Unsound & segregated. Upper part of ingot	37
38	32	"	"	"	1898	"		" "	.495	.90	.110	.095		116260	74130	7.00	6.31	"	Unsound and somewhat brittle.	38
39	3	"	A.S.C.E.	"	1899	"		" "	.647 .733 .648	1.00	.151 .126 .155	.197		118610	72490	13.0	15.03	"	Unsound and segregated badly.	39
40	21	"	"	"	1902	"		" "	.293	.89	.098	.162		108340	92860	14.00	16.17	"	Unsound and containing slag.	40

(4) The cause of the breakage of Nos. 14, 15 and 16 is unknown. They were all three broken at or in the splice, and the track and roadbed conditions were good. In two cases the ballast is stone, and in one gravel. Nos. 14 and 16 were on tangent, and 15 the low rail of a 3° and 28′ curve with 8-in. elevation, but the speed at this point is high and the track not on a steep grade. Rail No. 15, being of the P. S. section, was reported to be the "C" rail in the ingot. No. 16 is an open hearth rail made by the Carnegie Steel Co., and its hardness is at the upper limit of the specification, but otherwise there is no indication of hardness from the chemistry, and the tensile test does not show brittleness. It is possible that unusual strains were induced in these rails.

(5) Nos. 1 and 2 failed from a lap in the base, due to rolling.

RAILS WHICH FAILED FROM CRUSHED OR SPLIT HEADS.

(6) The results of the examination of twenty-four rails of A. S. C. E., P. S., A. R. A.-A and P. R. R. sections, which failed on the Southwest System of the Pennsylvania Lines West of Pittsburgh from crushed or split heads are given, and it will be noticed that all of the failures were caused either by hard, brittle, unsound or segregated material or a combination of two or more of them.

(7) Nos. 37, 17, 38 and 39 were selected because of the long time it took to develop the split heads, in spite of the defective material. Nos. 37, 17 and 38 are of 85-pound P. R. R. section, 1895, 1896 and 1898, respectively, while No. 39 is 85-pound A. S. C. E. 1899 rail. It thus took 14 years in the first case, 13 in the second, 12 in the third, and 10 in the fourth, to bring forward the development of the split-head sufficiently far to produce failure. In all cases the track and roadbed conditions were good at the time of failure, the ground being not frozen. The ballast was gravel in each case, and the track alinement straight.

In the case of No. 37 the phosphorus is badly segregated, being .170 at the place of analysis.

In the case of No. 17 the elastic limit, 90,320 pounds per square inch, is very high, but, in the case of single chemical analysis made, no segregation was shown.

In the case of No. 38 the metal is somewhat brittle, the elongation per cent. in 2 ins. being 7.00, and the reduction of area per cent. of original section 6.31.

In the case of No. 39 the carbon and phosphorus are both badly segregated and too high for Bessemer steel.

(8) Nos. 34, 35 and 36 are 100-pound A. R. A-A section, Bessemer steel, rolled by the Carnegie Steel Co. Two of them were on the low side of a 3° and 30′ curve, with elevation of 8 in. in one case, and 5½ ins. in the other, while the third, No. 36, was on tangent. The track conditions were good, the ballast being stone, although the ground was frozen in the case of Nos. 35 and 36. It will be observed, however, that the material was brittle and unsound, being especially brittle in the case of 35 and 36, while the constituents of 34 and 35 are segregated. The examination, therefore, shows the material to be exceedingly bad.

(9) In the case of No. 27 the carbon, .841, and the phosphorus, .168, indicate bad segregation and are high figures for Bessemer steel—the manganese, at the same time, being 1.09.

The tensile strength and the elastic limit were the same, being 96,990 pounds per square inch, while the elongation per cent. in 2 ins. was only 1.00, and the reduction of area per cent. of original section 1.98. This is a dreadfully bad material, and must indicate very poor practice in making ingots, as the rail in question is reported as "G," although it is probably "C."

(10) No. 40 is an 85-pound A. S. C. E. Carnegie Bessemer rail of the year 1902, and shows a most peculiar fracture, the head being split horizontally instead of vertically. The track conditions were good and the roadbed not frozen, but a very peculiar condition in regard to the carbon analysis is noted, the carbon being only .293 at the place where the sample was taken, due, probably, to the presence of slag, which is indicated by the etched photograph. It will also be noticed that the elastic limit is very high, 92,860 pounds per square inch.

(11) The most peculiar failures of all, however, are shown by Nos. 23, 24 and 25, which indicate very careless mill practice at the Gary mill. In each of these rails foreign material was rolled in the rail section, and it is very apparent in the case of No. 23 that the foreign material is an old tie plate. While these rails are of open hearth steel, the analysis clearly showed that this included material was Bessemer steel. The trouble appears to have occurred from the practice at the Gary mill of throwing pieces of scrap on the stool to prevent its cutting during the casting of the ingot. These three cases were caught at random on two separate divisions.

It seems to me that these forty cases of rail failures point out very clearly that the prime cause of rail failures is the poor quality of the material, as indicated by hardness, brittleness, segregation and unsoundness, all of which must be corrected in the ingot. Only two cases of faulty rolling were found in this lot.

DISCUSSION BY WICKHORST.

Mr. Cushing's discussion covers the matter nicely, and this is simply given as supplemental. In order to show up the results of the laboratory tests somewhat more clearly, in condensed form, the results of the "broken" rails given in Table 1 are plotted in Fig. 1, and the results of the "crushed and split head" rails given in Table 2 are plotted in Fig. 2. These figures show graphically the carbon, phosphorus, manganese, tensile strength and elongation. On these diagrams are also shown lines representing the specification limits for carbon, phosphorus and manganese as given in the specifications of February, 1910, namely, carbon, .45 per cent. to .55 per cent.; phosphorus, not over .10 per cent., and manganese, .80 per cent. to 1.10 per cent. A minimum limit for elongation has not been established, but probably Bessemer rail steel should give at least 12 per cent. stretch in 2 ins. in metal below the "brittle" zone at the top of the ingot and I show a line on the diagram at 12 per cent. for convenience of comparison.

Broken Rails.—Considering, first, the broken rails, probably the most

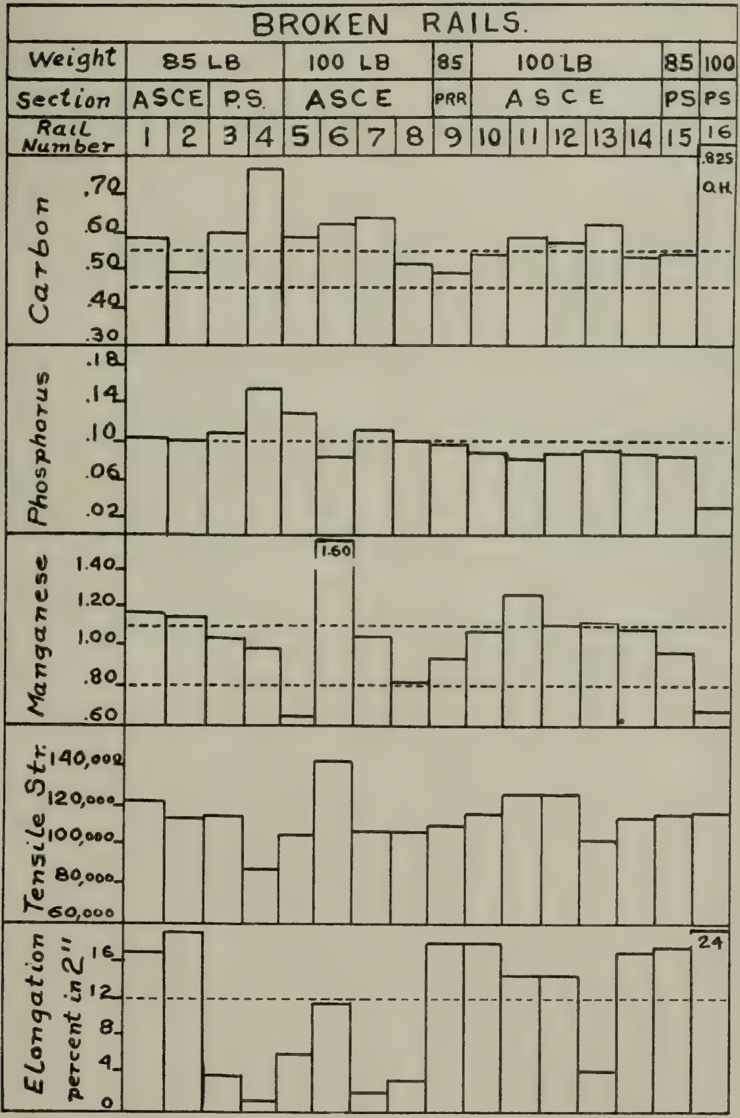

FIG. 1.

prominent feature shown by Fig. 1 is that the carbon of 9 of the 15 Bessemer rails is above the upper limit, although seriously so only in two or three cases. The phosphorus is below, or only a little above, the limit of .10 per cent. except in two cases, Nos. 4 and 5, which are considerably above. Seven of the rails show elongation below 12 per cent., and in these

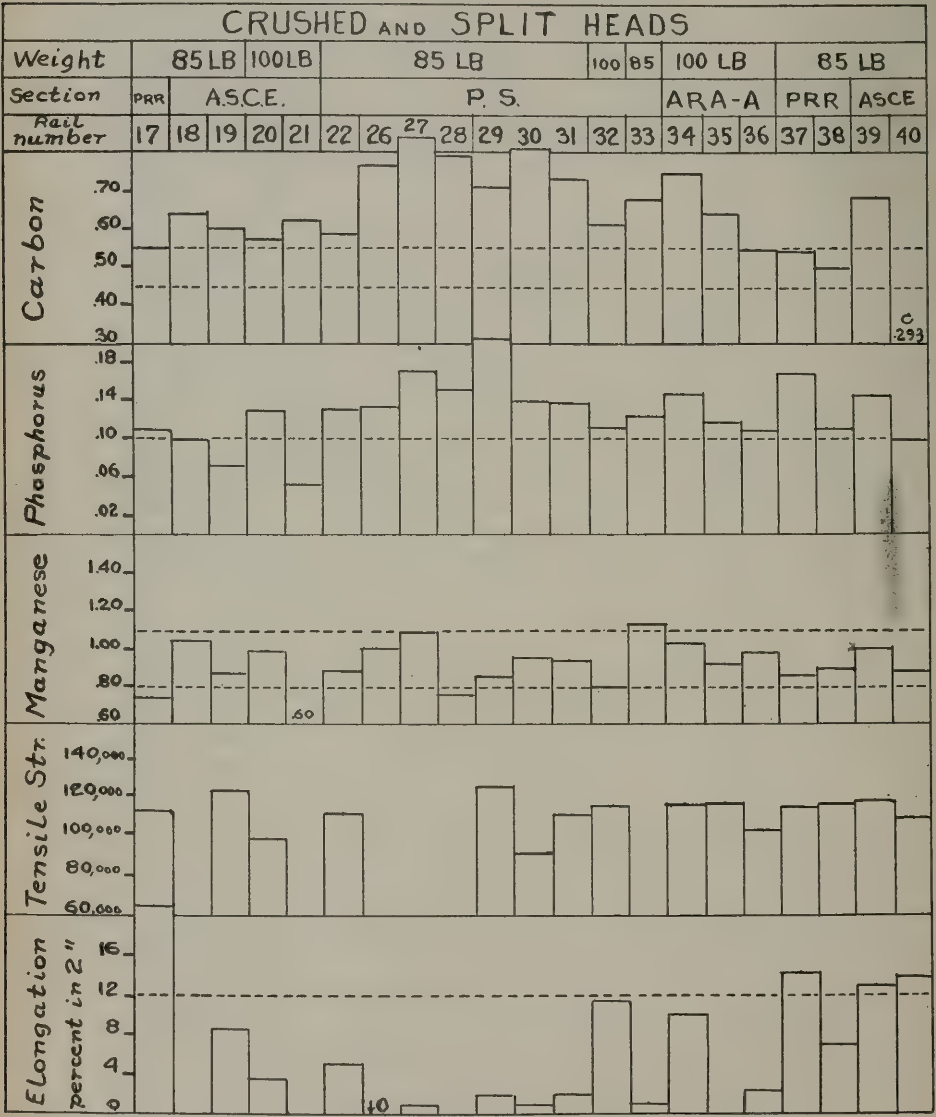

FIG. 2.

cases except one the carbon or phosphorus, or both, are above the upper limits. In about half or a little less of the "broken" rails it may be said, therefore, that the metal was not of first quality, and the etchings indicate them as coming mostly from the upper part of the ingot. This still leaves at least half of the cases where the metal must be pronounced good rail steel. Mr. Cushing has already stated that 13 of the 16 breaks occurred at or near the splice. These two latter statements rather suggest that failures classed as "broken" rails are due primarily to some very severe, and probably abnormal, condition of service or handling and that poor rail metal is much more liable to failure than the better metal of the rail bar. The failures are equally divided between good rail steel and what may be termed poorer metal, but it is probable that there is only a small proportion of the latter in service.

Crushed and Split Heads.—It will be noted from Fig. 2 that in almost all cases the carbon is above the upper limit of .55 per cent. for Bessemer steel, and in a large proportion of the cases very much so. The phosphorus also is, in most cases, above the maximum limit of .10 per cent., and here again a large proportion is considerably so. This combination of high carbon and high phosphorus means brittle material. The manganese in general comes within the specified limits or but little outside, and it apparently is not a factor in the matter of failure. The elongation is below 12 per cent. in 17 out of the 21 cases, and in most of them very much so, showing that, as a class, the metal in the interior of the head in this type of failure is very brittle, which would of course result from the high carbon and high phosphorus.

A study of the etchings shows that most of the rails in this class are from the upper part of the ingot, and the high carbon and phosphorus are therefore evidently due to segregation.

This study would indicate, therefore, that crushed and split head failures in Bessemer rails are confined mostly to rails of segregated metal from the upper part of the ingot.

INDIVIDUAL RAILS.

The rest of this report covers the information concerning the individual rails. The following abbreviations are used:

C = carbon.
P = phosphorus.
Mn = manganese.
S = sulphur.
Si = silicon.
T. S. = tensile strength.
E. L. = elastic limit.
Elong. = elongation.
Red. area = reduction of area.

(1) BROKEN RAIL.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1906; laid in May, 1906, on a one-degree curve, gravel ballast, and removed October 13, 1909. Rail was broken two ft. from joint; square break.

C .584; Mn 1.17; P .102; Si .110; T. S. 122,440 lbs. per sq. in.; E. L. 69,430 lbs. per sq. in.; Elong. in 2 in., 17.0%; Red. area 27.15%.

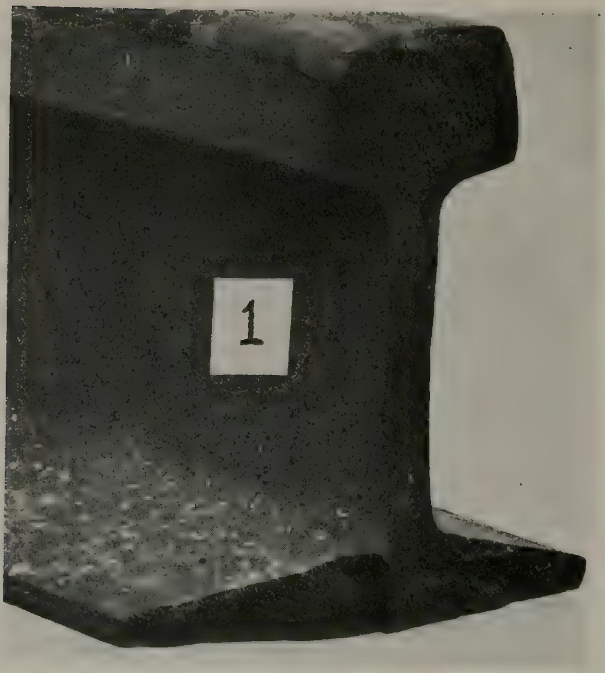

FIG. 3. RAIL I.

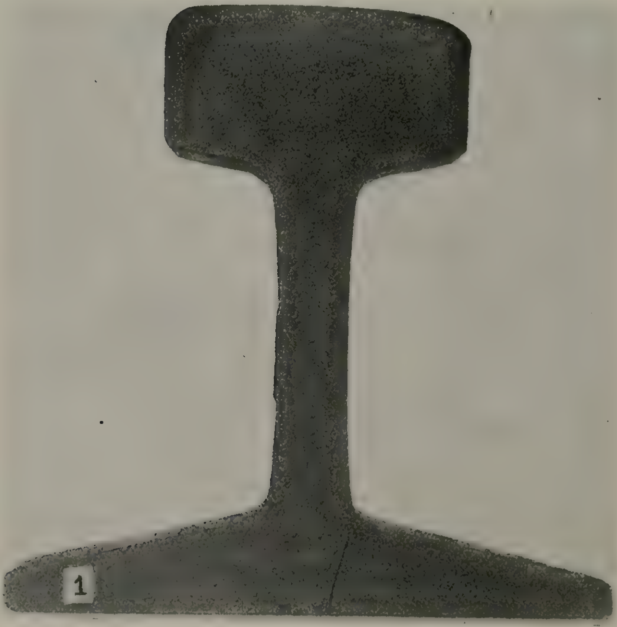

FIG. 4. RAIL I.

(2) BROKEN RAIL.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, October, 1907; laid in January, 1909, on straight line, stone ballast, and removed on October 11, 1909. Rail was broken two ft. from receiving end; the character of the fracture of this rail indicated that the rail first failed by breaking out of the flange.

C .487; Mn 1.14; P .100; Si .113; T. S. 113.390 lbs. per sq. in.; E. F. 67,130 lbs. per sq. in.; Elong. in 2 in., 19.0%; Red. area. 33.79%.

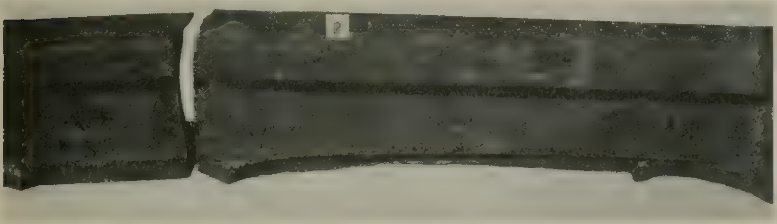

FIG. 5. RAIL 2.

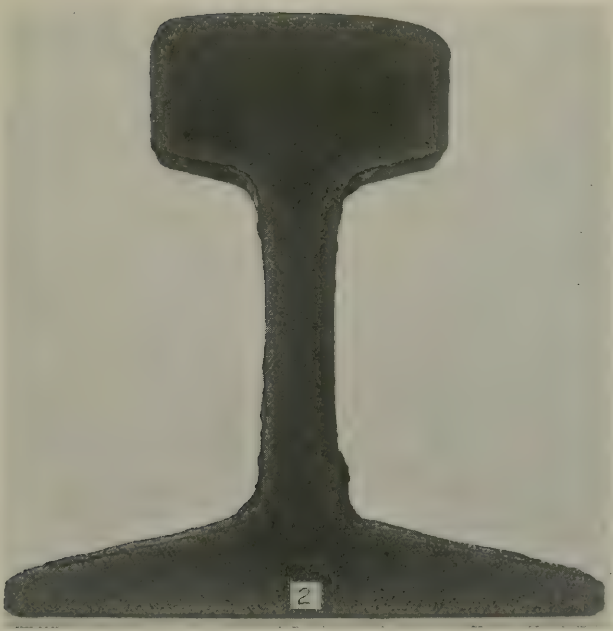

FIG. 6. RAIL 2.

(3) BROKEN RAIL.

85-lb. P. S. Bessemer, made by Illinois Steel Company, South Works, June, 1909; laid in June, 1909, on straight line, gravel ballast, and removed on October 19, 1909. Angular break just beyond bolt holes; six-hole angle bar, full bolted.

C .596; Mn 1.03; P .106; Si .143; T. S. 114,210 lbs. per sq. in.; E. L. 72,240 lbs. per sq. in.; Elong. in 2 in., 3.50%; Red. area 0.00%.

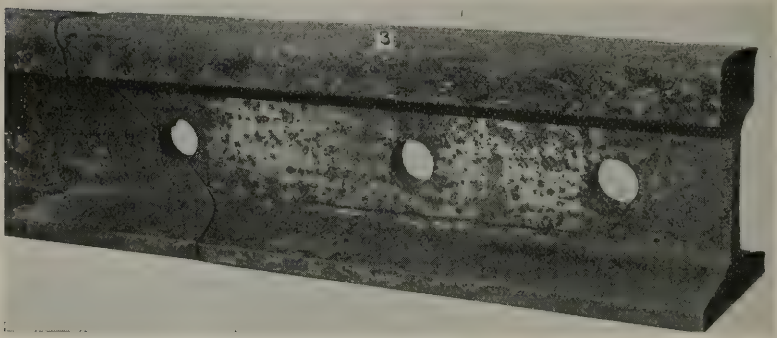

FIG. 7. RAIL 3.

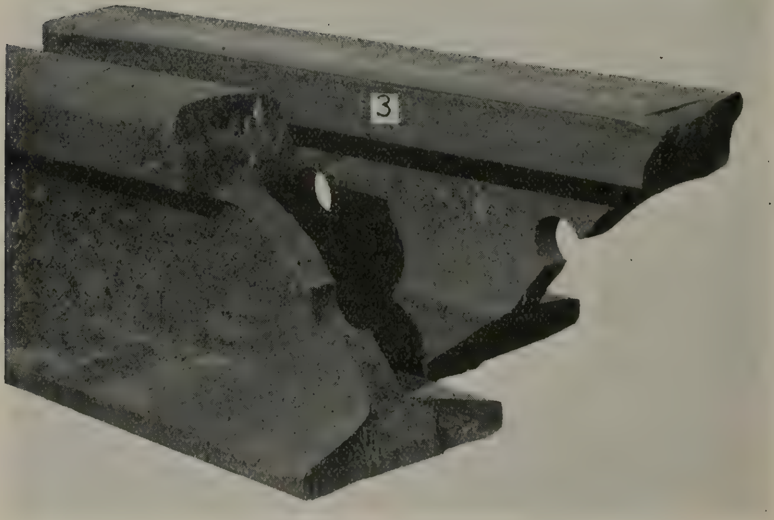

FIG. 8. RAIL 3.

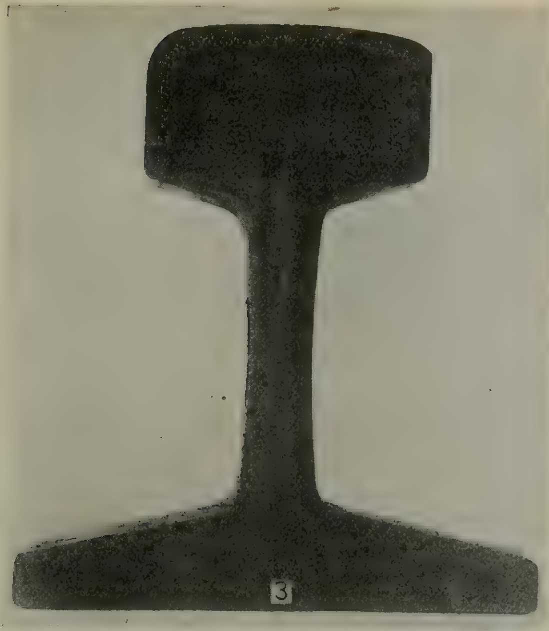

FIG. 9. RAIL 3.

(4) BROKEN RAIL.

85-lb. P. S., made by Illinois Steel Company, South Works, April, 1909; laid in May, 1909, on straight line, gravel ballast; removed August 4, 1909. Angular break four in. from end through bolt hole; six-hole splice.

C .771; Mn .98; P .154*; Si .176; S .078; T. S. 87,470 lbs. per sq. in.; E. L. 75,970 lbs. per sq. in.; Elong. in 2 in., 1.00%; Red. area 0.00%.

*Average of 5 determinations ranging from .133 to .168%.

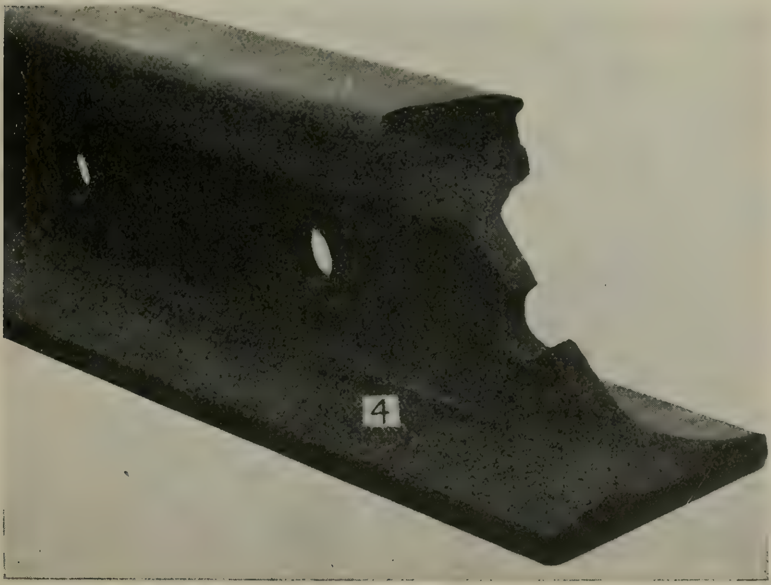

FIG. 10. RAIL 4.

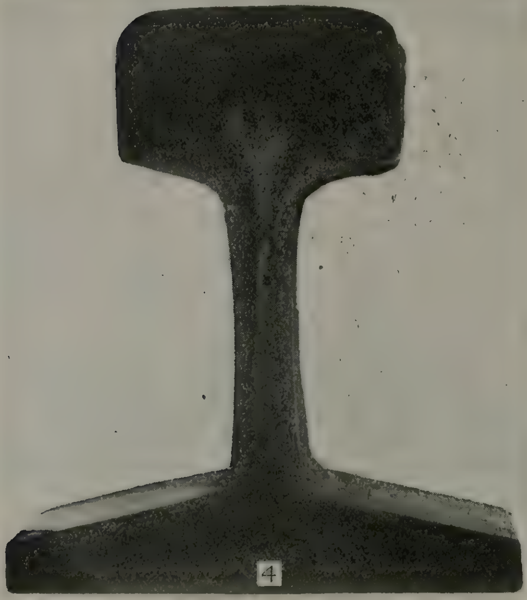

FIG. 11. RAIL 4.

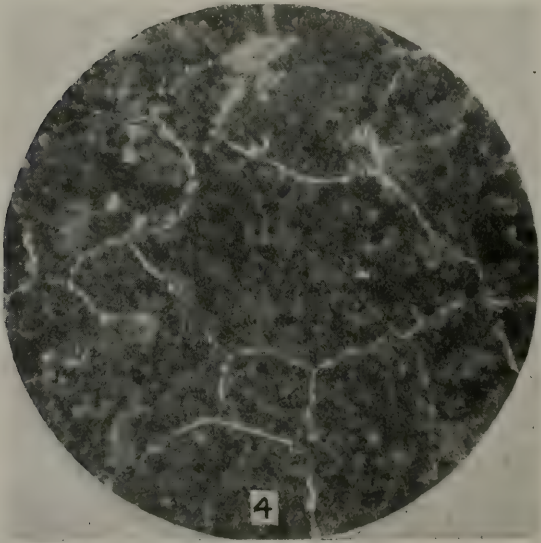

FIG. 12. RAIL 4, CENTER OF HEAD, ETCHED WITH PICRIC ACID—MAGNIFIED 100 DIAMETERS.

(5) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, February, 1907; laid in February, 1907, on straight line on bridge, no ballast; removed December 18, 1909. Angular break nine in. from receiving end through bolt holes, six-hole insulated Weber joint.

C .578; Mn .64; P .126; Si .068; T. S. 104,230 lbs. per sq. in.; E. L. 66,580 lbs. per sq. in.; Elong. in 2 in., 5.00%; Red. area 6.26%.

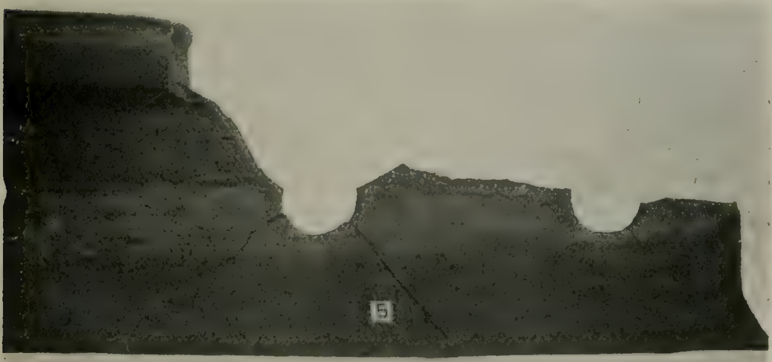

FIG. 13. RAIL 5.

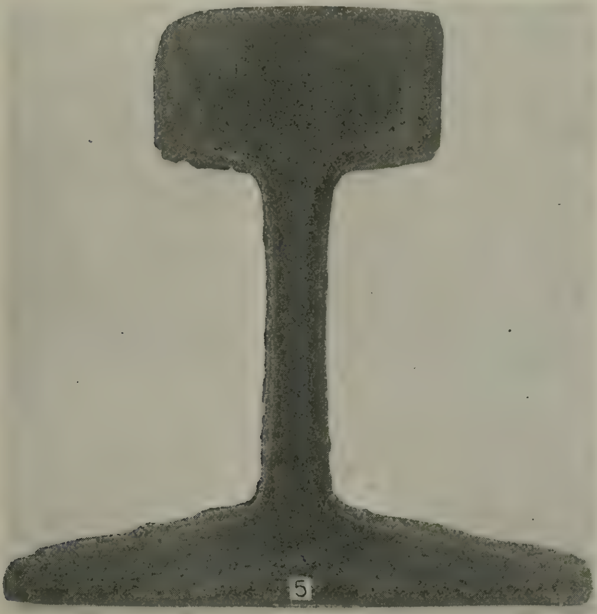

FIG. 14. RAIL 5.

(6) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1907; laid in June, 1907, on straight line, stone ballast; removed December 30, 1909. Angular break about one-third of length of rail from receiving end; weather frosty.

C .618; Mn 1.60; P .081; Si .156; T. S. 141,400 lbs. per sq. in.; E. L. 98,450 lbs. per sq. in.; Elong. in 2 in., 11.50%; Red. area 14.75%.

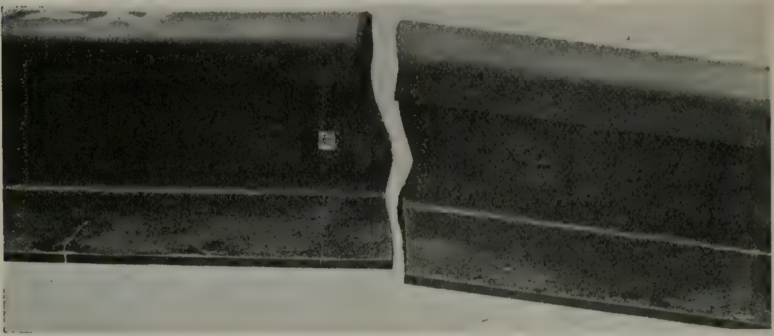

FIG. 15. RAIL 6.

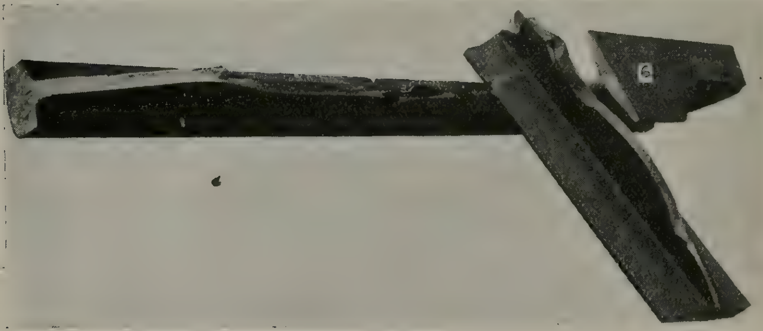

FIG. 16. RAIL 6.

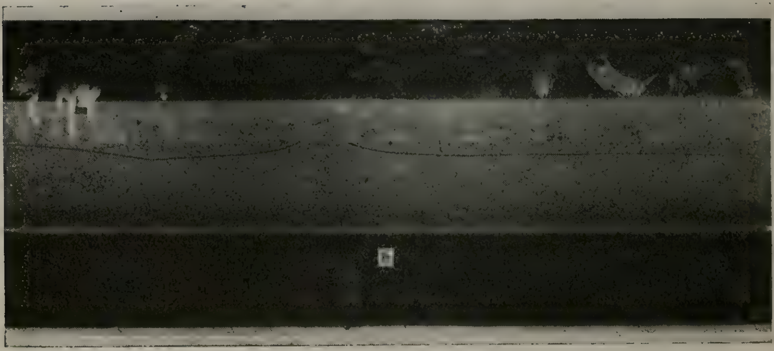

FIG. 17. RAIL 6, CRACK IN WEB ABOUT CENTER OF RAIL.

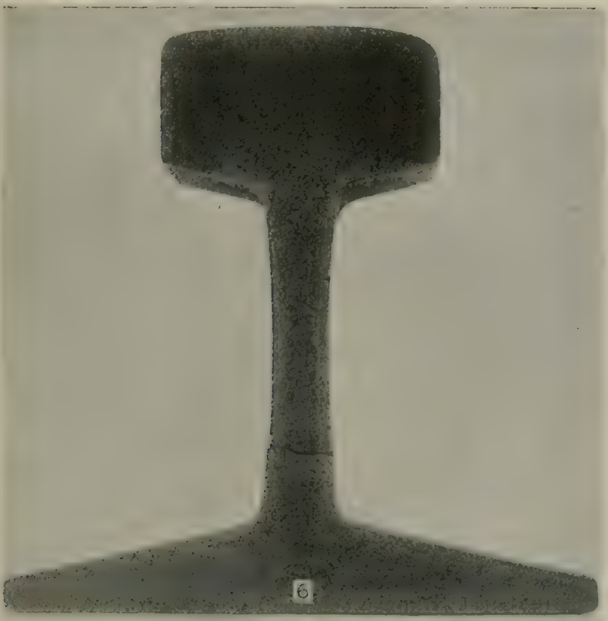

FIG. 18. RAIL 6.

(7) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, July, 1906; laid in July, 1906, low rail of three-degree 50-min. curve, limestone ballast; removed December 13, 1909. Angular break five in. from receiving end; standard six-hole insulated Weber joint.

C .644; Mn 1.03; P .112; Si .100; T. S. 107,460 lbs. per sq. in.; E. L. 79,750 lbs. per sq. in.; Elong. in 2 in., 2.00%; Red. area 2.81%.

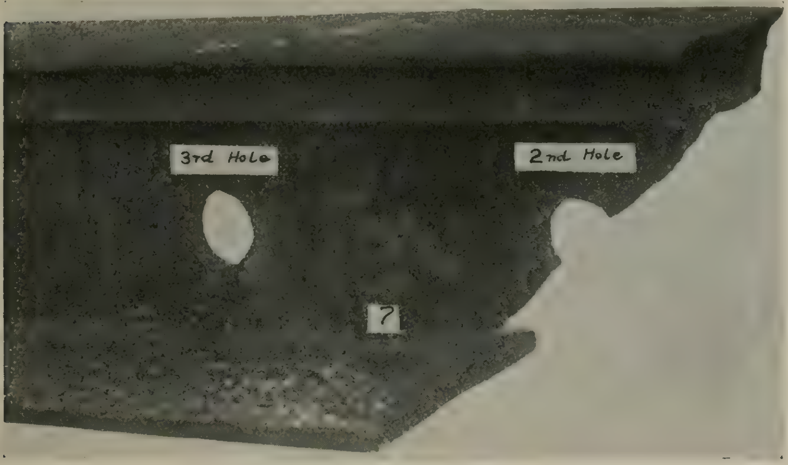

FIG. 19. RAIL 7.

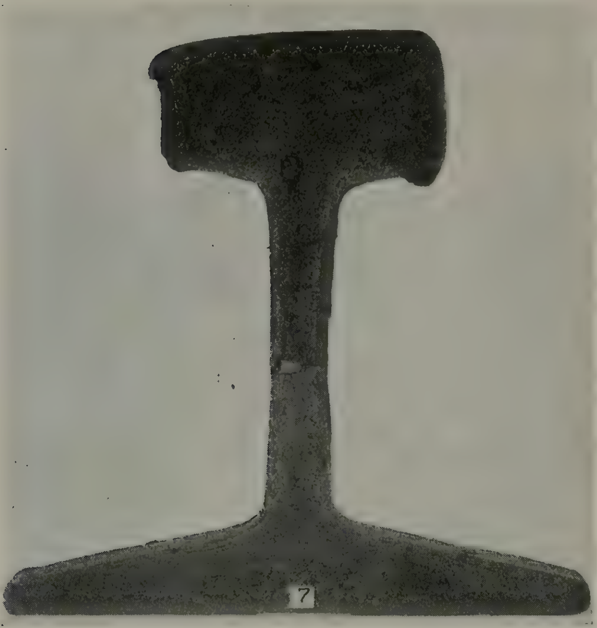

FIG. 20. RAIL 7.

(8) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works; laid in July, 1902, on straight line, stone ballast; removed December 30, 1909. Angular break through bolt holes; Bonzano six-hole, full-bolted joint.

C .509; Mn .81; P .099; Si .065; T. S. 106,320 lbs. per sq. in.; E. L. 72,640 lbs. per sq. in.; Elong. in 2 in., 3.00%; Red. area 3.56%.

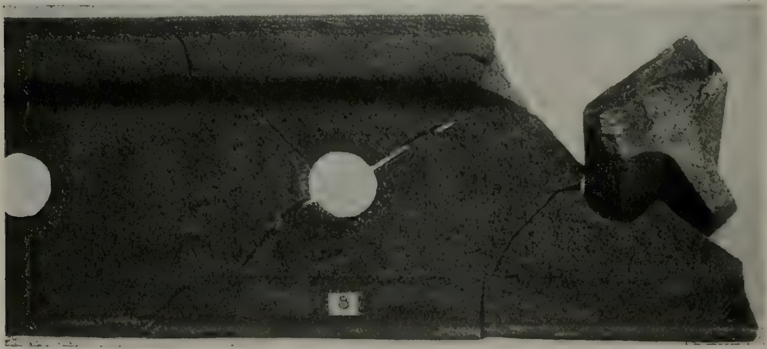

FIG. 21. RAIL 8.

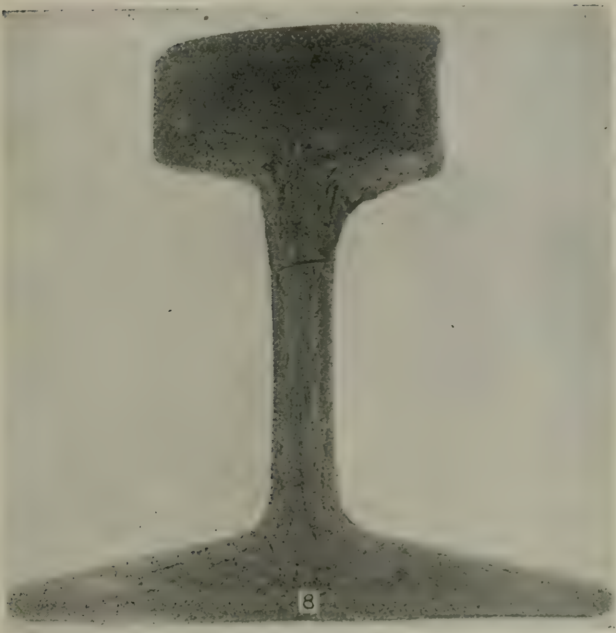

Fig. 22. Rail 8.

(9) BROKEN RAIL.

85-lb. P. R. R., made by Illinois Steel Company; laid in June, 1895, on straight line, gravel ballast; removed November 18, 1909. Angular break 17 in. from receiving end; plain six-hole angle bar. At point of failure the flange was very thin, due to corrosion.

C .490; Mn .93; P .096; Si .204; T. S. 110,210 lbs. per sq. in.; E. L. 80,080 lbs. per sq. in.; Elong. in 2 in., 18.00%; Red. area 30.23%.

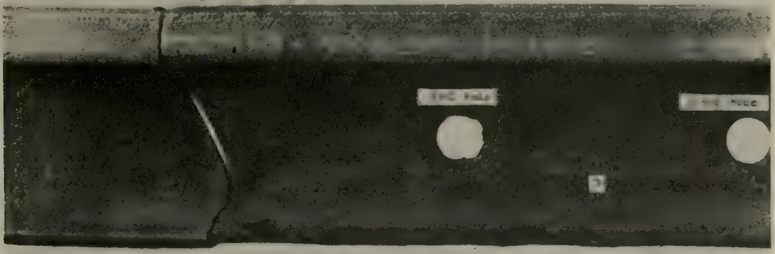

Fig. 23. Rail 9.

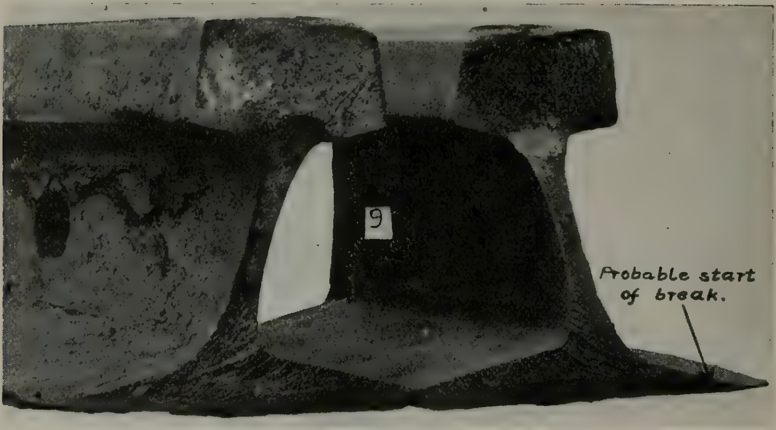

FIG. 24. RAIL 9.

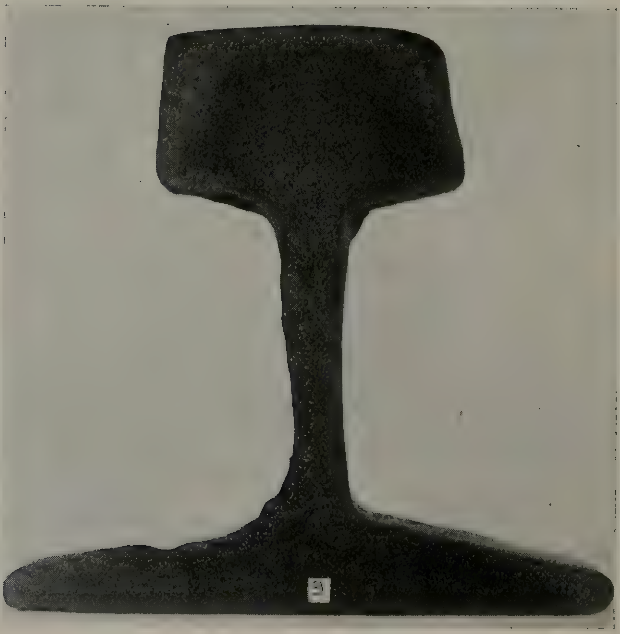

FIG. 25. RAIL 9.

(10) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, February, 1906; laid in February, 1906, on straight line, stone ballast; removed, November 20, 1909. Angular break between second and third bolt holes; standard hole joint, full bolted, not insulated. The section of the rail at the point of fracture and over the entire length of the splice-bar contact had been worn very thin.

C .541; Mn 1.06; P .085; Si .120; T. S. 115,750 lbs. per sq. in.; E. L. 92,590 lbs. per sq. in.; Elong. in 2 in., 18.00%; Red. area 10.53%.

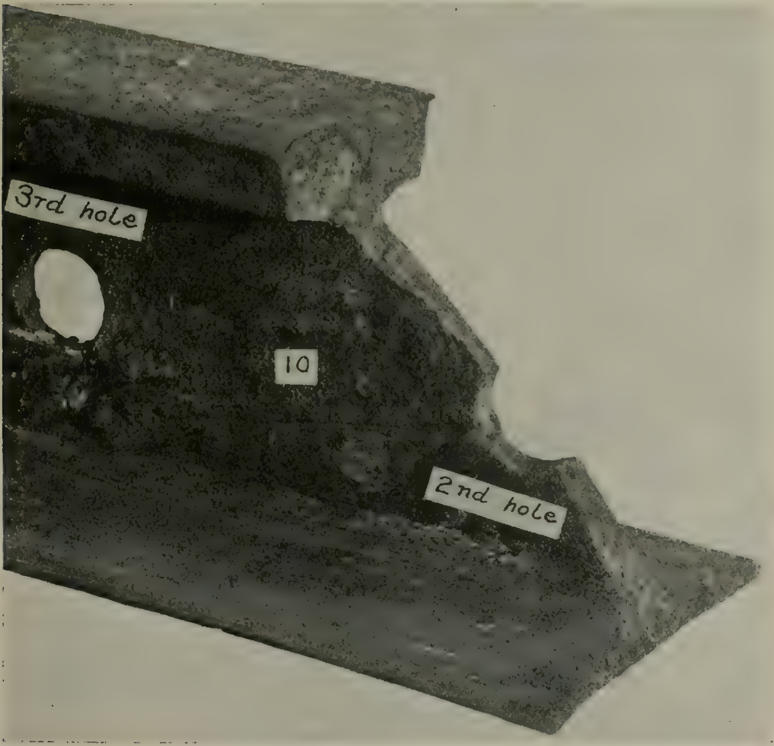

FIG. 26. RAIL 10.

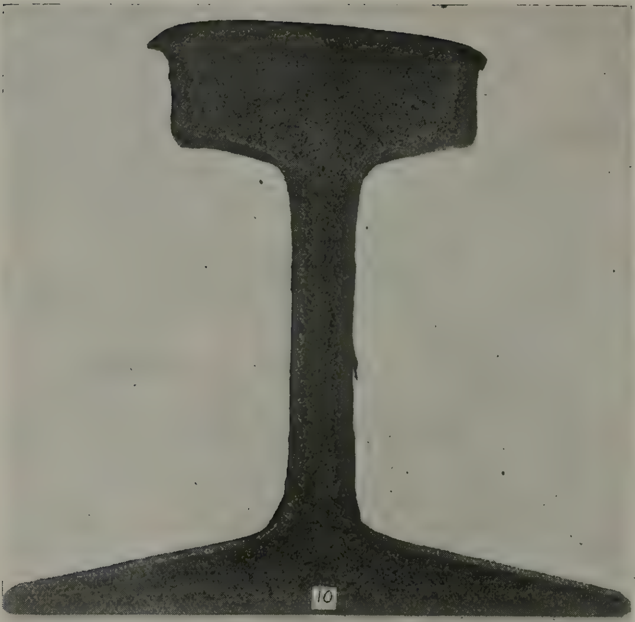

FIG. 27. RAIL 10.

(11) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, February, 1906; laid February, 1906, on low rail of three-degree and 16-min. curve, stone ballast; removed October 13, 1909. Angular break through second bolt hole at leaving end; standard six-hole, full-bolted joint.

C .576; Mn 1.26; P .081; Si .129; T. S. 125,200 lbs. per sq. in.; E. L 74,280 lbs. per sq. in.; Elong. in 2 in., 14.50%; Red. area 24.03%.

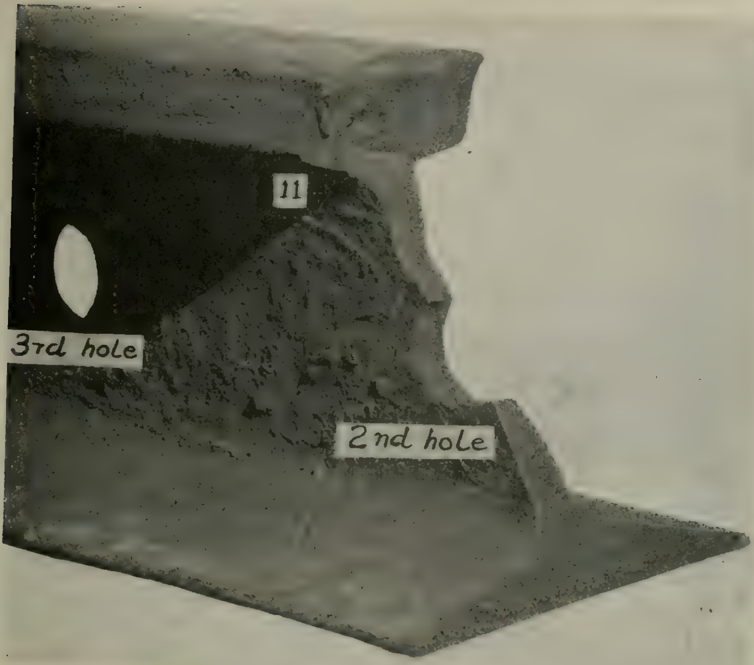

FIG. 28. RAIL 11.

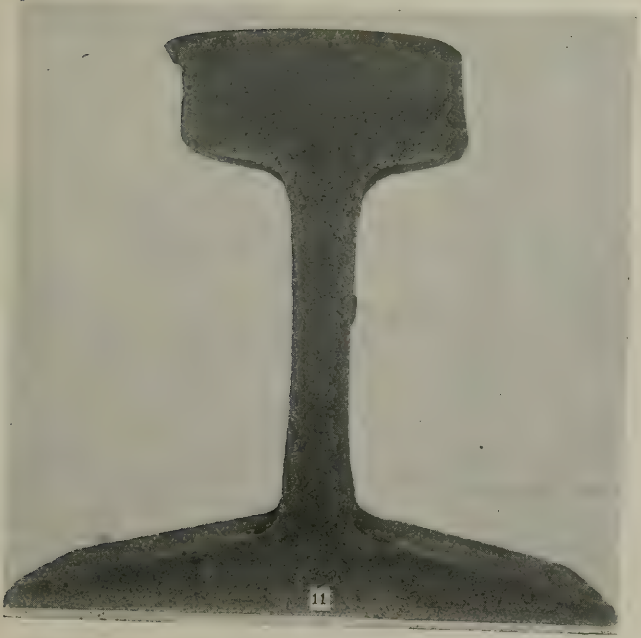

FIG. 29. RAIL 11.

(12) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, April, 1906; laid in April, 1906, on straight line, limestone ballast; removed December 23, 1909. Square break five in. from receiving end; standard six-hole, full-bolted, not insulated joint.

C .566; Mn 1.10; P .085; Si .091; T. S. 125,560 lbs. per sq. in.; E. L. 83,950 lbs. per sq. in.; Elong. in 2 in., 14.50%; Red. area 19.78%.

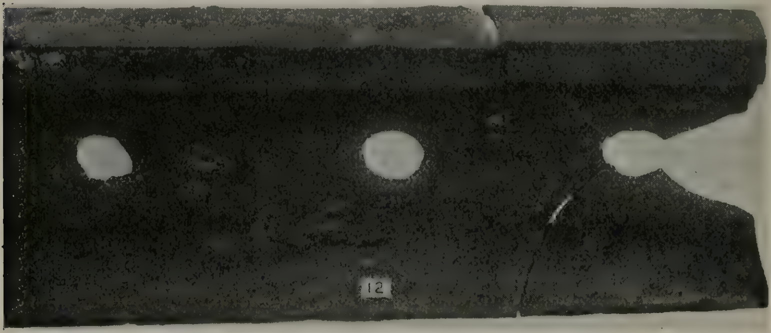

FIG. 30. RAIL 12.

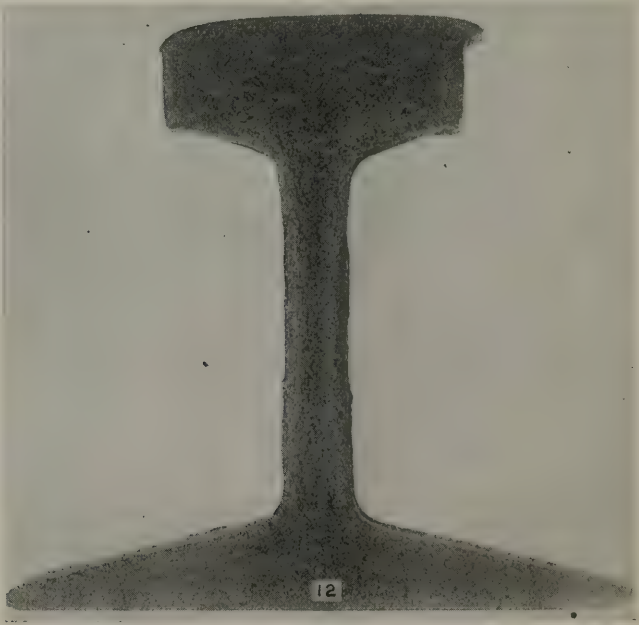

FIG. 31. RAIL 12.

(13) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, 1906; laid in February, 1906, on straight line, stone ballast; removed November 28, 1909. Angular break between first and second and second and third bolt holes; flaw between bolt holes half way between base and head; standard six-hole, full-bolted, not insulated joint.

C .622; Mn 1.11; P .090; Si .096; T. S. 100,920 lbs. per sq. in.; E. L. 100,920 lbs. per sq. in.; Elong. in 2 in., 4.00%; Red. area 3.15%.

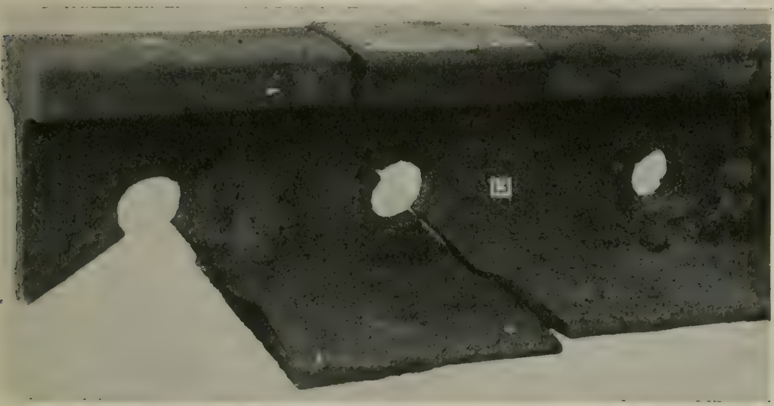

FIG. 32. RAIL 13.

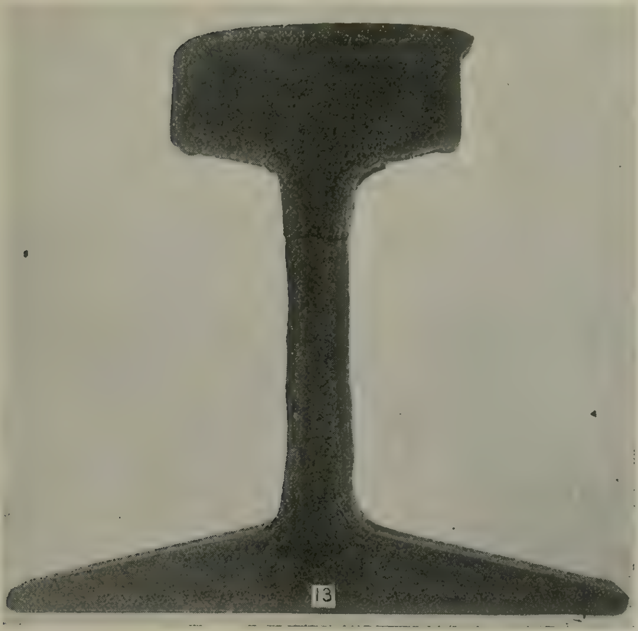

FIG. 33. RAIL 13.

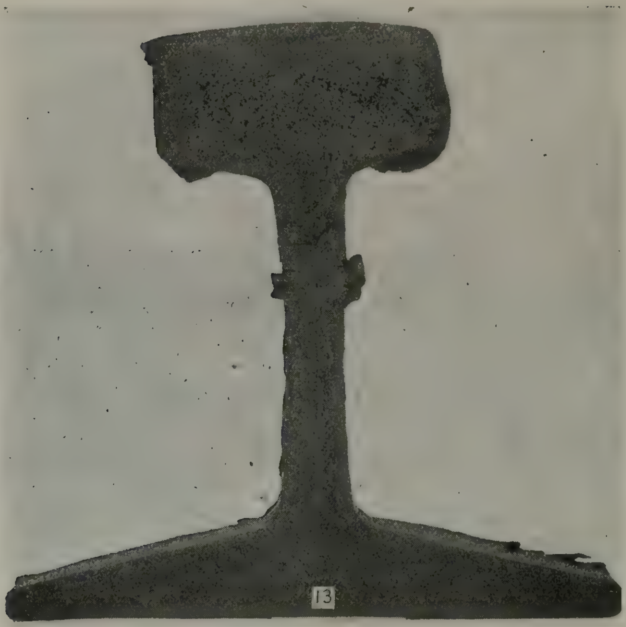

FIG. 34. RAIL 13.

(14) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, February, 1906; laid in February, 1906, on straight line, stone ballast; removed October 11, 1909. Break at receiving end seventeen in. from end at the top of the rail and fifteen in. at the bottom; standard six-hole, full-bolted joint.

C .529; Mn 1.08; P .086; Si .126; T. S. 117,370 lbs. per sq. in.; E. L. 66,230 lbs. per sq. in.; Elong. in 2 in., 17.00%; Red. area 31.07%.

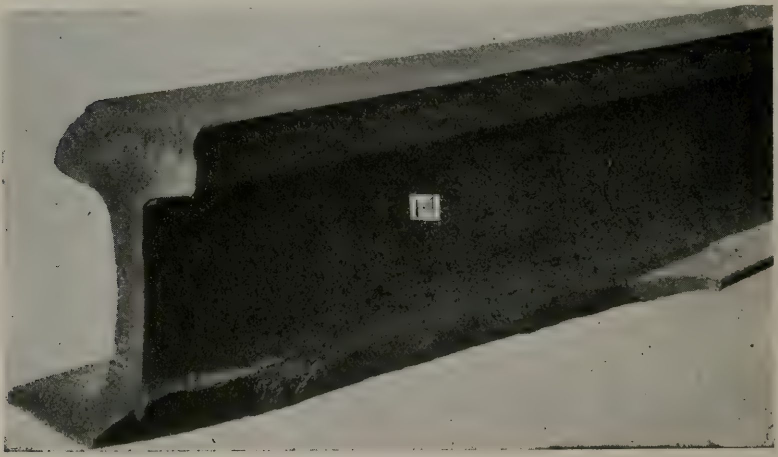

FIG. 35. RAIL 14.

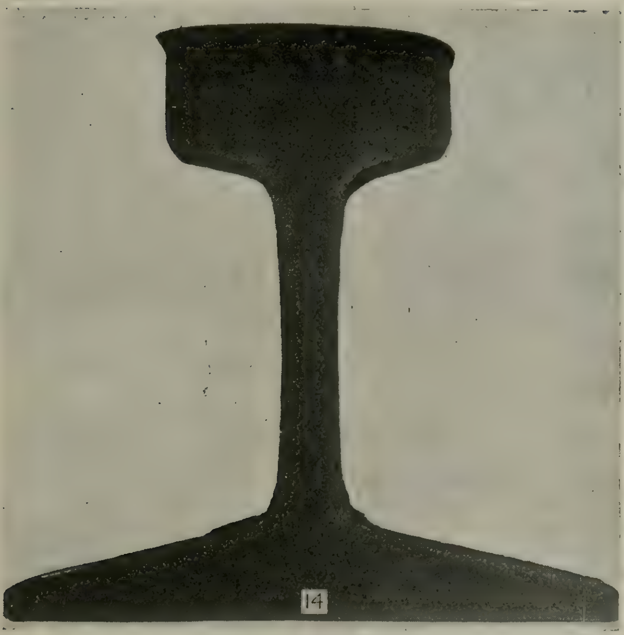

FIG. 36. RAIL 14.

(15) BROKEN RAIL.

85-lb. P. S. Bessemer, made by Illinois Steel Company, April, 1909, Heat No. 33456, letter "C;" laid in May, 1909, on low rail on three-degree 28-min. curve, in gravel ballast; removed November 15, 1909. Square break at leaving end, caused by crack in web through bolt hole; P. S. splice, six-hole, full bolted.

C .544; Mn .96; P .092; Si .183; T. S. 114,930 lbs. per sq. in.; E. L. 69,380 lbs. per sq. in.; Elong. in 2 in., 17.50%; Red. area 29.19%.

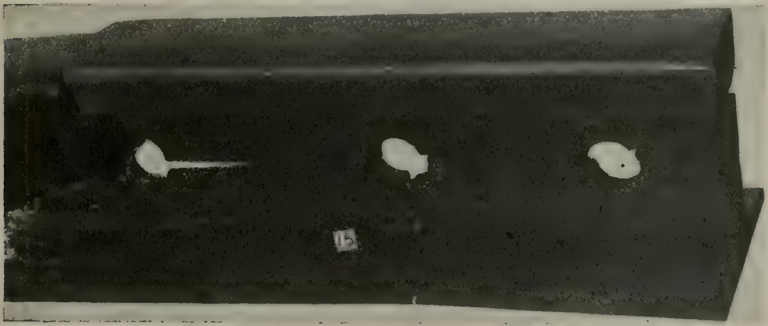

FIG. 37. RAIL 15.

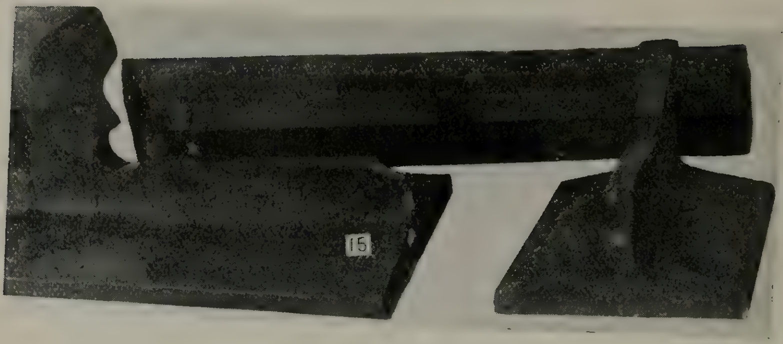

FIG. 38. RAIL 15.

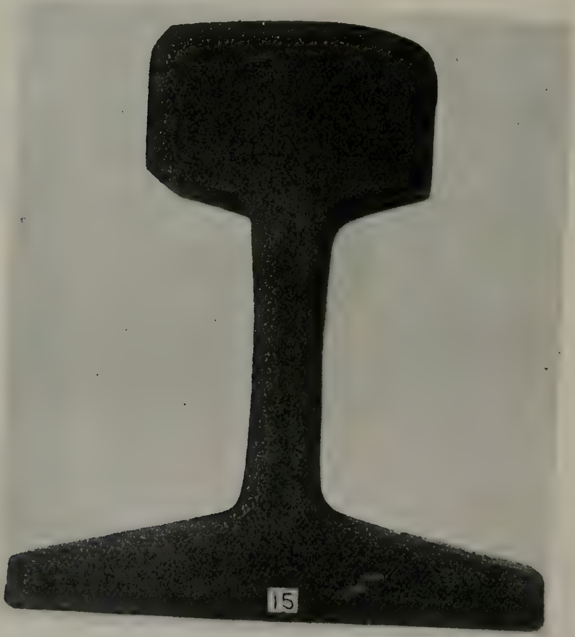

FIG. 39. RAIL 15.

(16) BROKEN RAIL.

100-lb. P. S.-O. H., made by Carnegie Steel Company, Edgar Thomson Works, March, 1909. Heat No. 55116, letter "A;" laid in April, 1909, on straight line, screened gravel ballast; removed December 7, 1909. Angular break; bolt was split through stem and broken in two parts; six-hole O. H. angle bar, full bolted, not insulated.

C .825; Mn .68; P .032; Si .109; T. S. 116,260 lbs. per sq. in.; E. L. 99,230 lbs. per sq. in.; Elong. in 2 in., 24.00%; Red. area 28.83%.

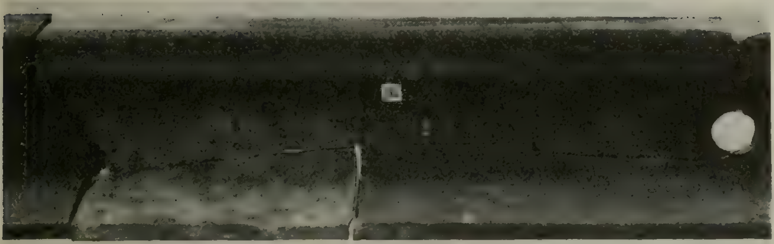

FIG. 40. RAIL 16.

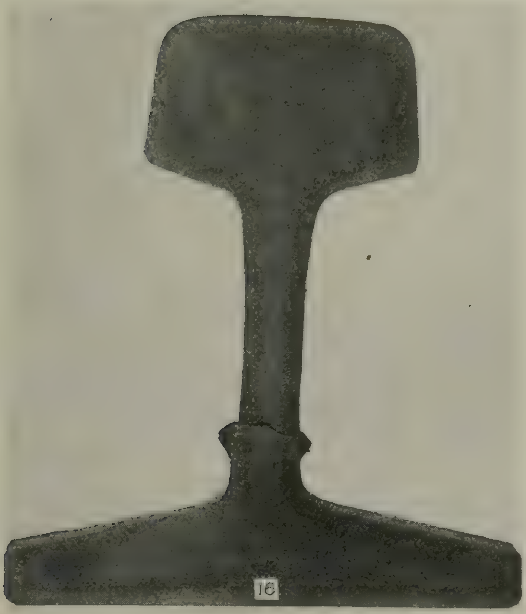

FIG. 41. RAIL 16.

(17) CRUSHED HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, Edgar Thomson Works, November, 1896, Heat No. 1613; laid in December, 1896, on straight line, gravel ballast; removed December 7, 1909. Six in. of crushed head, twelve in. from end of rail.

C .549; Mn .74; P .111; Si .065; T. S. 112,230 lbs. per sq. in.; E. L. 90,320 lbs. per sq. in.; Elong. in 2 in., 21.00%; Red. area 18.23%.

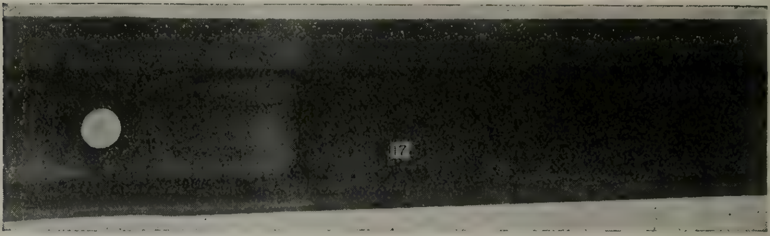

FIG. 42. RAIL 17, SHOWING CRACK UNDER HEAD.

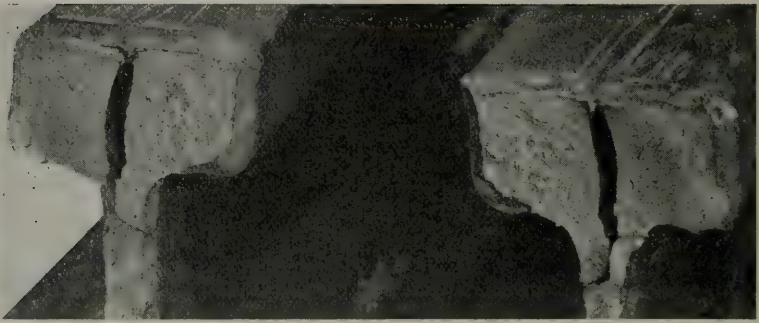

FIG. 43. RAIL 17.

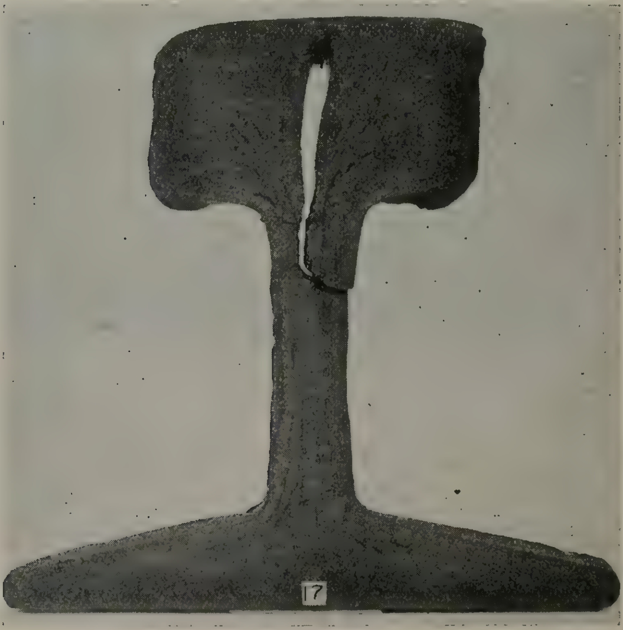

FIG. 44. RAIL 17.

(18) CRUSHED HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1905; laid in May, 1905, on straight line, screened gravel ballast; removed June 12, 1909. Head crushed for about fourteen ft. starting two ft. from receiving end.

C .043; Mn 1.04; P .098; Si .094; S .054; no tensile test made.

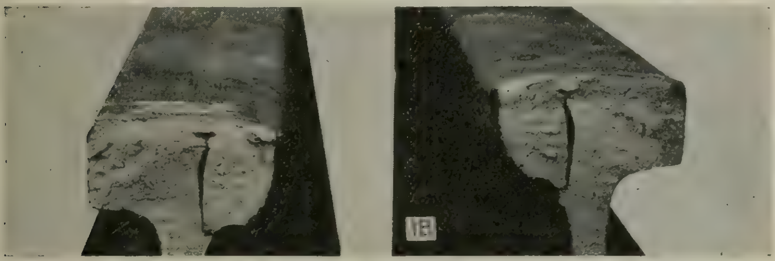

FIG. 45. RAIL 18, CUT 8 FT. FROM RECEIVING END.

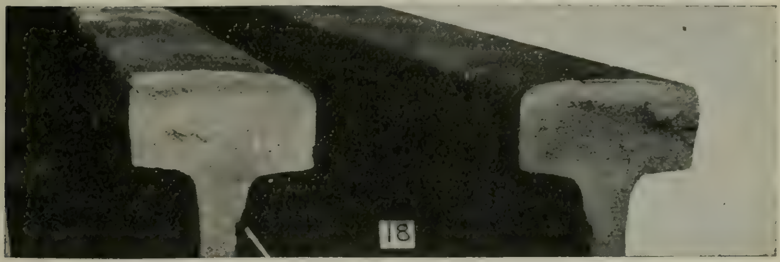

FIG. 46. RAIL 18, CUT 20 FT. FROM RECEIVING END.

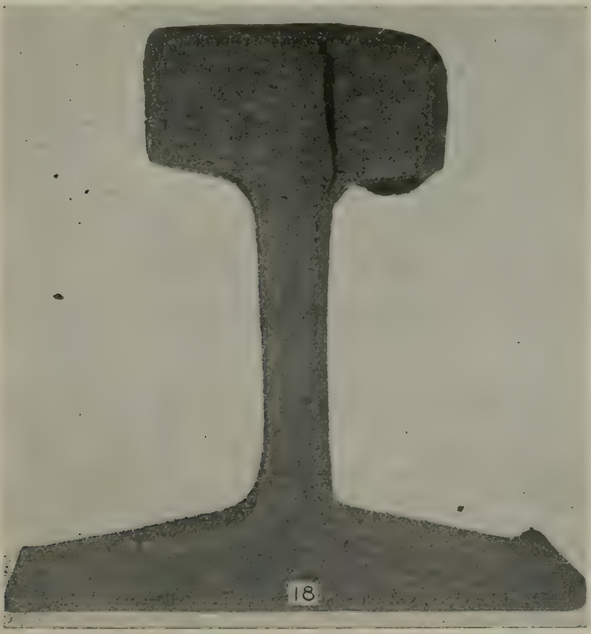

FIG. 47. RAIL 18.

(19) CRUSHED HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, February, 1906; laid in April, 1906, on low rail of one-degree 38-min. curve, gravel ballast; removed July 10, 1909. Head crushed for two and one-half ft. starting three ft. from receiving end.

C .598; Mn .88; P .072; Si .109; S .042; T. S. 124,180 lbs. per sq. in.; E. L. 76,120 lbs. per sq. in.; Elong. in 2 in., 8.50%; Red. area 9.25%.

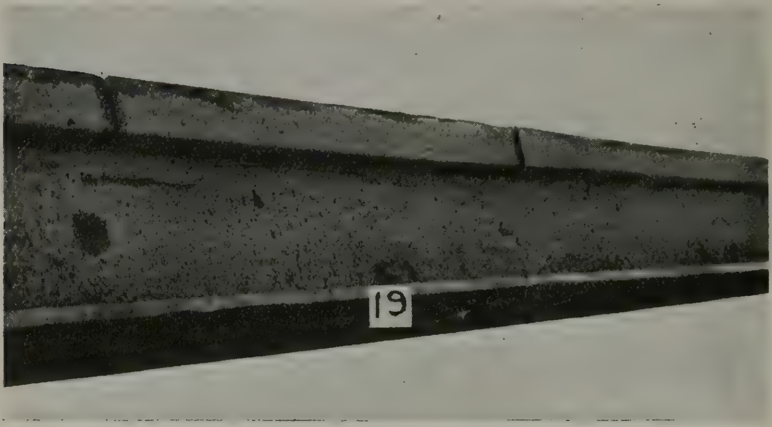

FIG. 48. RAIL 19, SHOWING CRACK UNDER HEAD.

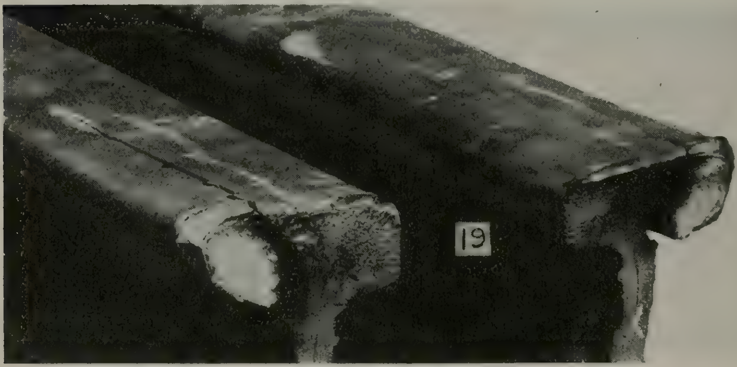

FIG. 49. RAIL 19.

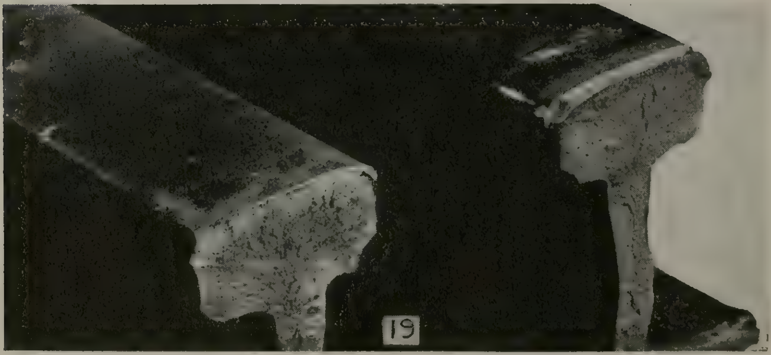

FIG. 50. RAIL 19, CUT 8 FT. 9 IN. FROM RECEIVING END.

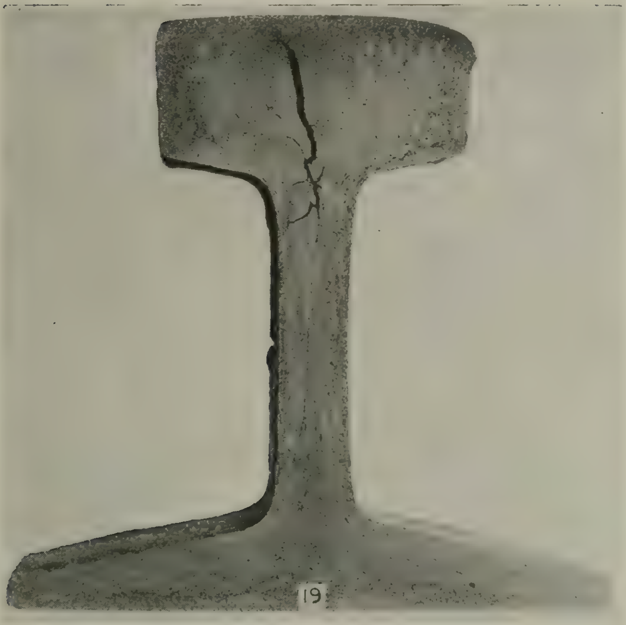

Fig. 51. Rail 19.

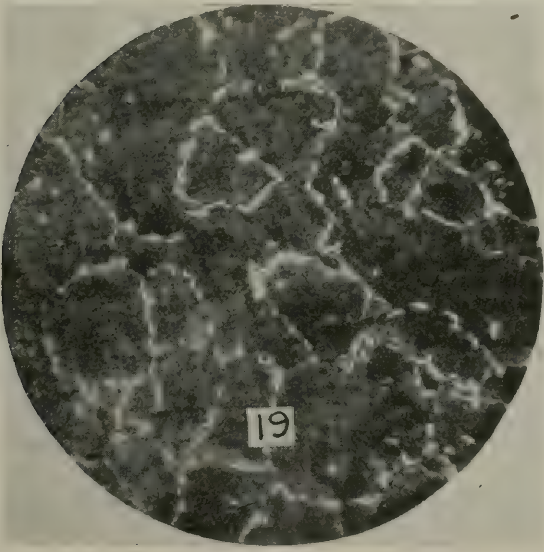

Fig. 52. Rail 19, Center of Head, Etched with Picric Acid—Magnified 100 Diameters.

(20) CRUSHED HEAD.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, July, 1906, Heat No. 301; laid August, 1906, on low rail on one-degree one-min. curve, limestone ballast; removed July 24, 1909. Head crushed for ten ft. starting 6½ ft. from leaving end.

C .571; Mn .99; P .127; Si .094; T. S. 98,050 lbs. per sq. in.; E. L. 66,940 lbs. per sq. in.; Elong. in 2 in., 3.50%; Red. area 0.00%.

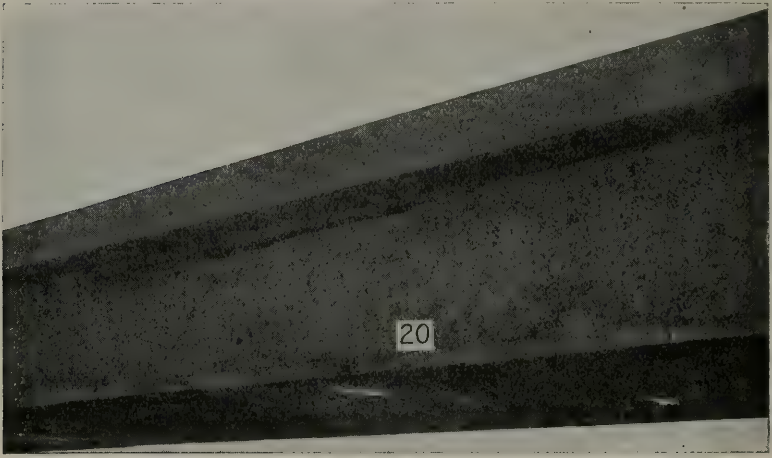

FIG. 53. RAIL 20, SHOWING CRACK UNDER HEAD.

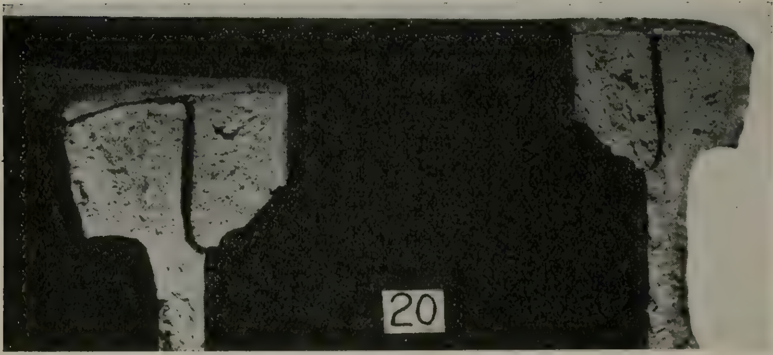

FIG. 54. RAIL 20, CUT 14 FT. 5 IN. FROM LEAVING END.

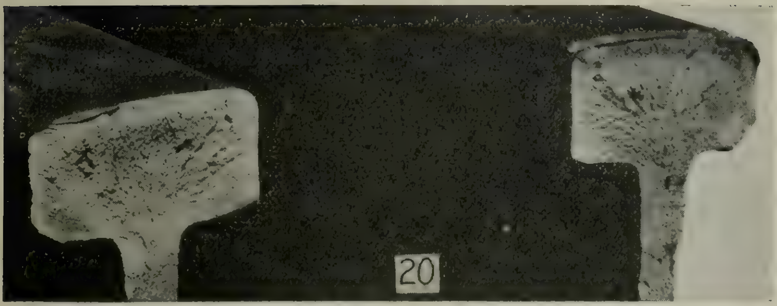

FIG. 55. RAIL 20, CUT 21 FT. 10 IN. FROM LEAVING END.

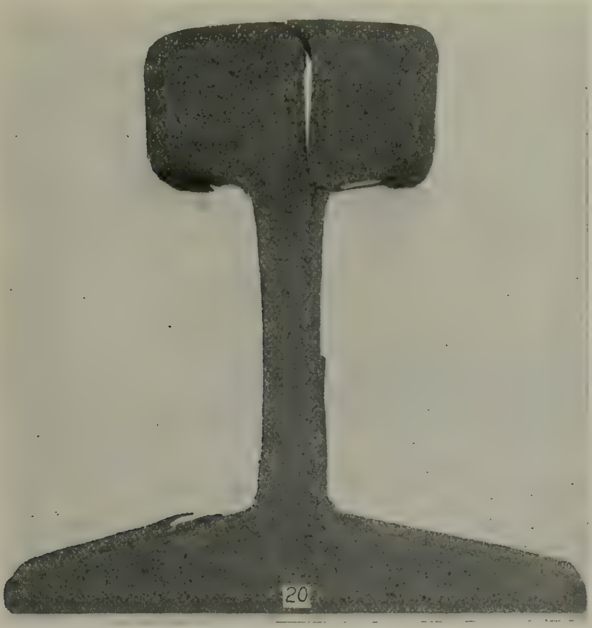

FIG. 56. RAIL 20.

(21) CRUSHED HEAD.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, February, 1907; laid in February, 1907, on low rail on five-degree 16-min. curve, limestone ballast; removed July 7, 1909. Head crushed for one ft. starting two ft. from leaving end.

C .580, .607, .641*; Mn .60; P .052; Si .063; S .044; no tensile test made.

*It was impossible to get check determinations from drillings taken from the head of this rail.

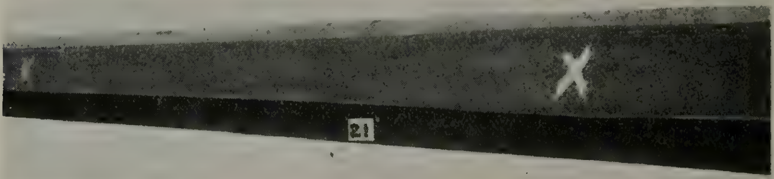

FIG. 57. RAIL 21, SHOWING WIDENING OF HEAD.

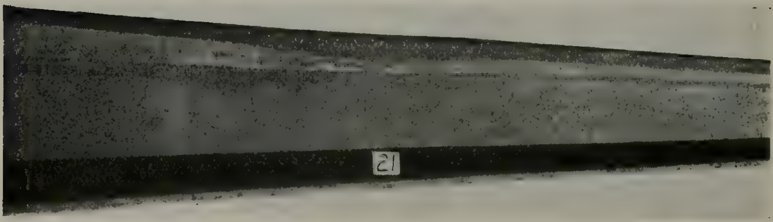

FIG. 58. RAIL 21.

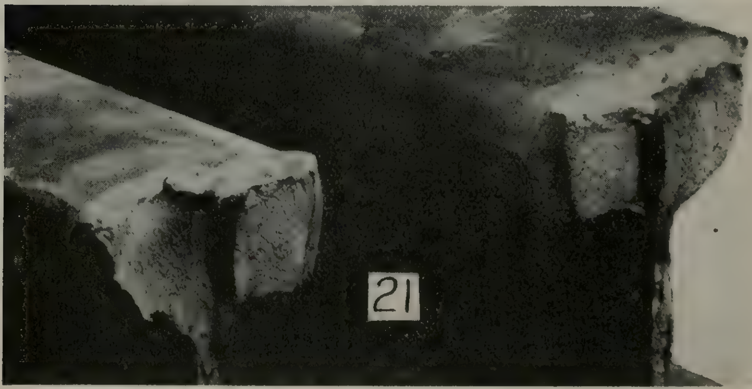

FIG. 59. RAIL 21. CUT 4 FT. 6 IN. FROM LEAVING END.

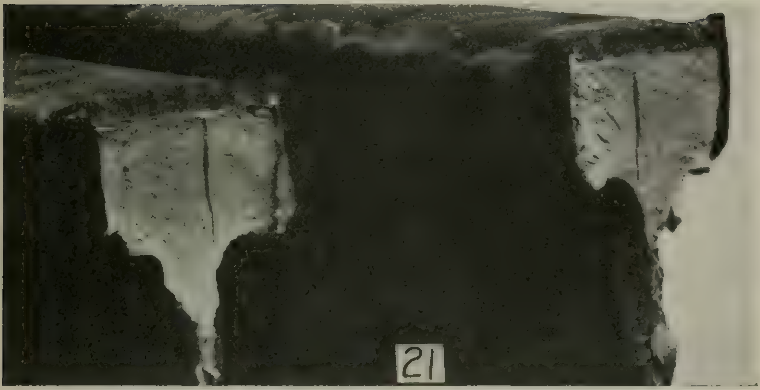

FIG. 60. RAIL 21, CUT 8 FT. 10 IN. FROM LEAVING END.

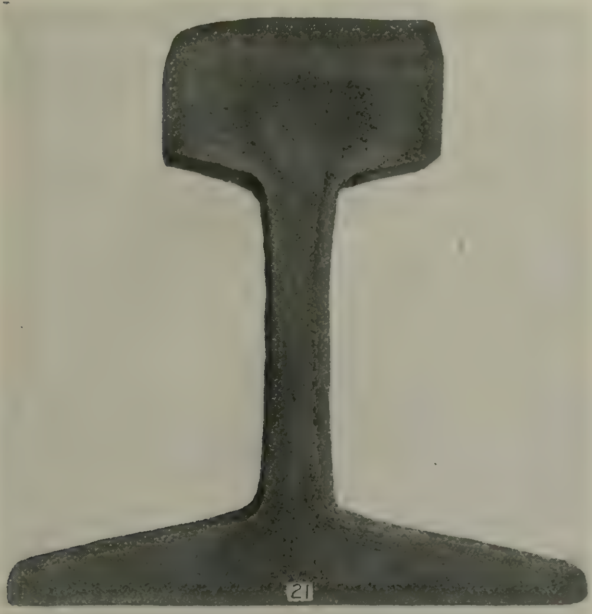

FIG. 61. RAIL 21.

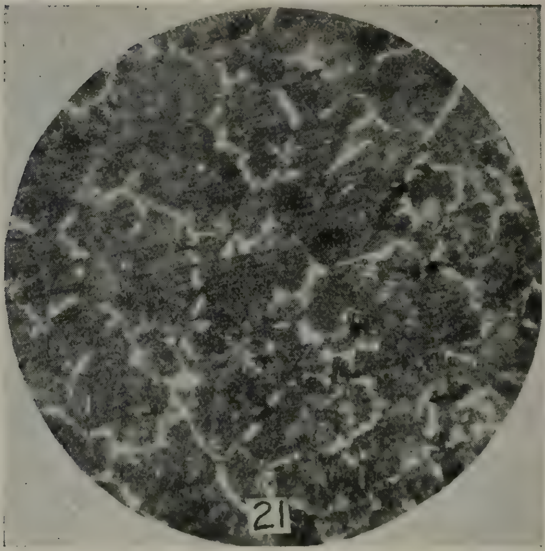

FIG. 62. RAIL 21, CENTER OF HEAD, ETCHED WITH PICRIC ACID—MAGNIFIED 100 DIAMETERS.

(22) CRUSHED HEAD.

85-lb. P. S., made by Illinois Steel Company, South Works, Heat No. 9437, letter "A;" laid May, 1909, on high rail on five-degree curve, gravel ballast; removed November 23, 1909. At two places the top of the head is flattened toward the inside of the rail; at other places the rail slivered off in strips about 1-16 in. by ¼ in. by 8 in.; unusual defect.

C .578; Mn .89; P .128; Si .072; T. S. 110,630 lbs. per sq. in.; E. L. 76,690 lbs. per sq. in.; Elong. in 2 in., 5.00%; Red. area 4.75%.

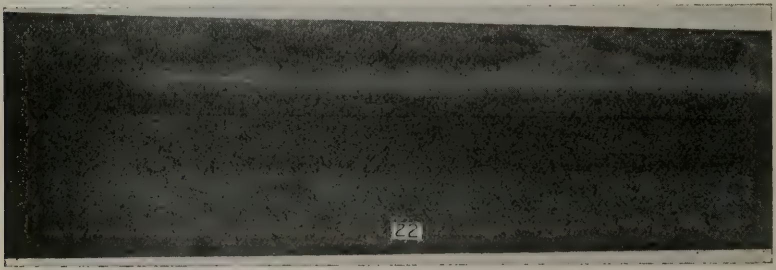

FIG. 63. RAIL 22, SHOWING SCALY HEAD.

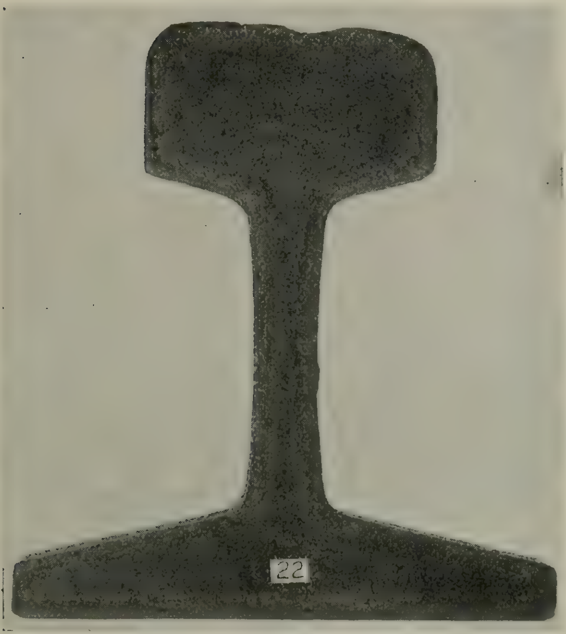

FIG. 64. RAIL 22.

(23) FLOW OF METAL.

85-lb. P. S. O.-H. Made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 3035, letter "C;" laid May, 1909, on low rail of three-degree 43-min. curve, gravel ballast; removed October 30, 1909. Head flow at receiving end for five ft. nine in. R. W. Hunt & Co. make the following comments:

"The inclusion of some foreign material in the steel of this rail is apparent in the photograph of the etching. The presence of this material was evidently the cause of the failure. Aside from this inclusion the steel was evidently sound and would give satisfactory service. This is shown by the results of chemical analysis, the appearance of the etching and the results of the tensile test.

"Drillings were carefully taken from the foreign material shown in the etching, and an analysis showed the following results:

	Location A.	Location B.
Percentage of carbon by combustion..	.535	.405
Percentage of phosphorus............	.051	.075
Percentage of manganese............	.62	.67

"Early Gary Open-Hearth practice made use of various small pieces of cold scrap on the tops of the stool in the casting of ingots. This was thrown into the moulds at random to prevent the ingots from sticking to the stool. Ordinarily this practice required a somewhat greater discard from the bottom of the ingot than would be necessary without the use of this scrap, but it has always been assumed that the discard was sufficient to eliminate all of this scrap material. This scrap has largely consisted of tie-plates, and considerable spikes, bolts and other general mill scrap. The section of the tie-plate which has been used is that shown on Fig. 68-A, and it is remarkable that the section indicated in the etching corresponds very closely to this section, leaving in our minds no reasonable doubt, but that the inclusion is that of a tie-plate. The analysis of these tie-plates is .20 to .30 per cent of carbon and about .10 per cent of phosphorus, and, while the analysis taken from the inclusion and reported above, shows percentage of carbon somewhat higher and a percentage of phosphorus somewhat lower than this analysis, the difference can be readily accounted for from the fact that in drilling the etching it was practically impossible to restrain the drillings within the area covered by the miniature tie-plate section."

C .735; Mn .70; P .025; Si .119; T. S. 122,020 lbs. per sq. in.; E. L. 72,380 lbs. per sq. in.; Elong. in 2 in., 13.50%; Red. area 0.27%.

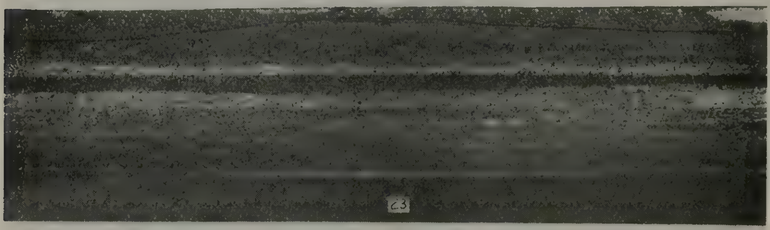

FIG. 65. -RAIL 23, TOP VIEW SHOWING "FLOW OF METAL."

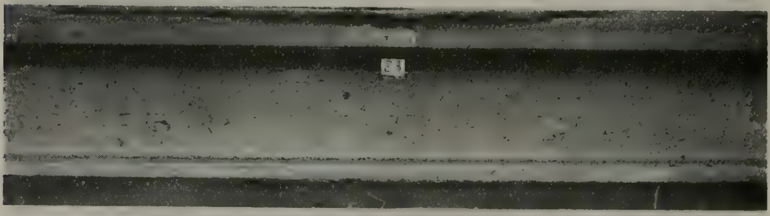

FIG. 66. RAIL 23, SIDE VIEW.

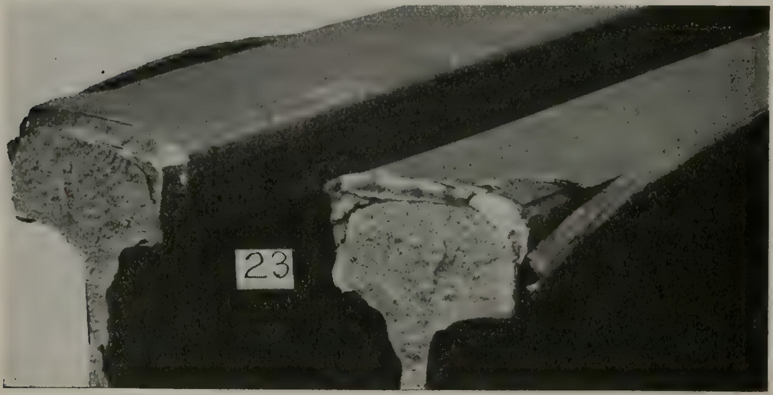

FIG. 67. RAIL 23.

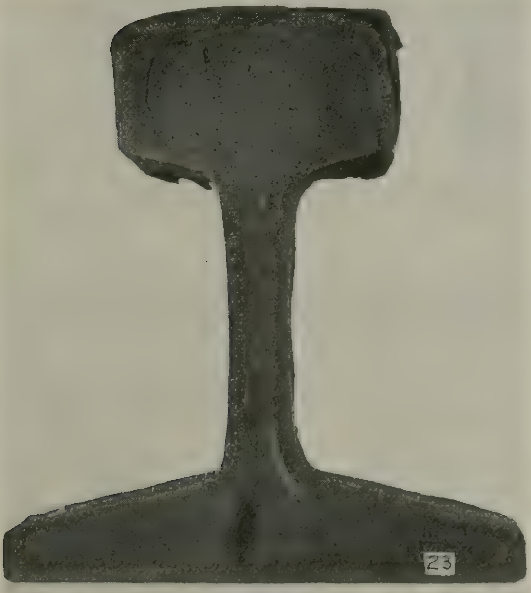

FIG. 68. RAIL 23.

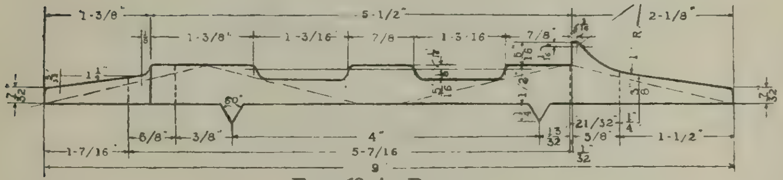

FIG. 68-A, RAIL 23.

(24) SPLIT HEAD.

85-lb. P. S. O.-H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 56050; laid July, 1909, on high rail of ten-degree curve, gravel ballast; removed September 1, 1909. Defect fifteen in. from leaving end of rail, extending back eight ft.; split head accompanied by same, defect watched twenty days. R. W. Hunt & Co. make following comments:

"The inclusion of foreign material in the steel of this rail was the cause of the failure. Consideration of our report of the 20th inst., under subject Failure of 85-lb. P. S., Gary, 1909, Rail West of M. P. 152, on Section No. 42, November 1, 1909, in connection with the examination of the etching, indicates that the foreign material was tie-plates. Our analysis of drillings taken from this material shows result as follows:

Percentage of carbon by combustion..............	.547
Percentage of phosphorus........................	.085
Percentage of manganese.........................	.66

"Aside from this inclusion the steel is apparently satisfactory, although the tensile test does show some brittleness."

C .680; Mn .740; P .027; Si .120; T. S. 110,580 lbs. per sq. in.; E. L. 70,140 lbs. per sq. in.; Elong. in 2 in., 5.00%; Red. area 0.10%.

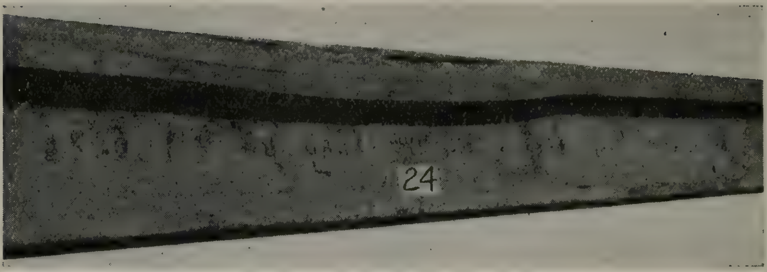

FIG. 69. RAIL 24, SHOWING SAG OF HEAD.

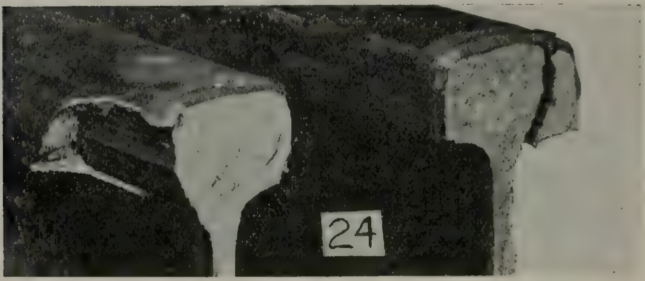

FIG. 70. RAIL 24.

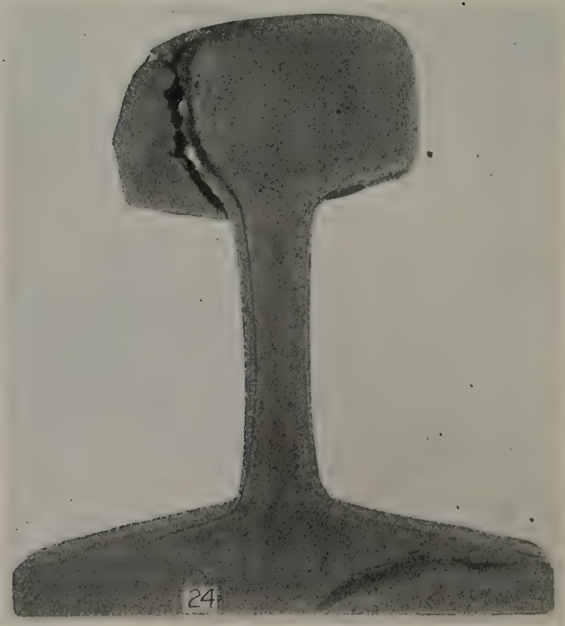

FIG. 71. RAIL 24.

(25) SPLIT HEAD.

85-lb. P. S. O.-H., made by Illinois Steel Company, Gary Works, 1909; laid July, 1909, on high rail of ten-degree curve; removed November 27, 1909. Split head running from 15 in. from east end of rail to 4 ft. from east end of rail, accompanied by seam 2 ft. 9 in. long; defect watched twelve days.

Mn .681; P .77; Si .025; S .080; T. S. 118,800 lbs. per sq. in.; E. L. 89,610 lbs. per sq. in.; Elong. in 2 in., 15.00%; Red. area 20.06%.

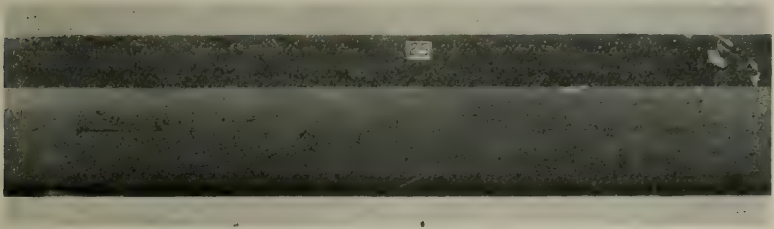

Fig. 72. Rail 25, Showing Scaly Head.

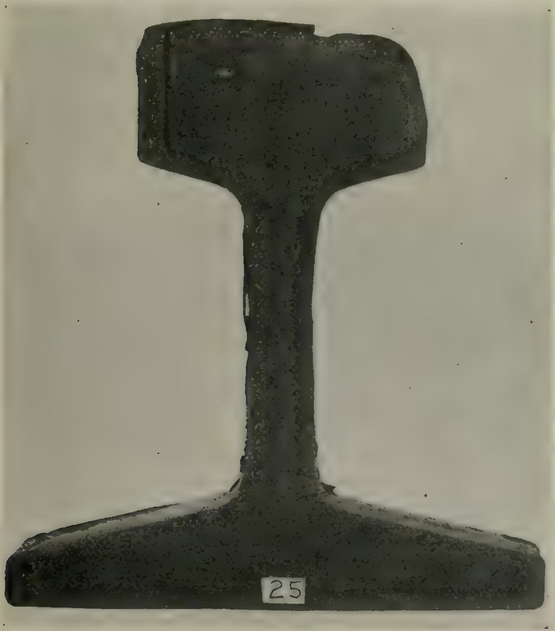

Fig. 73. Rail 25.

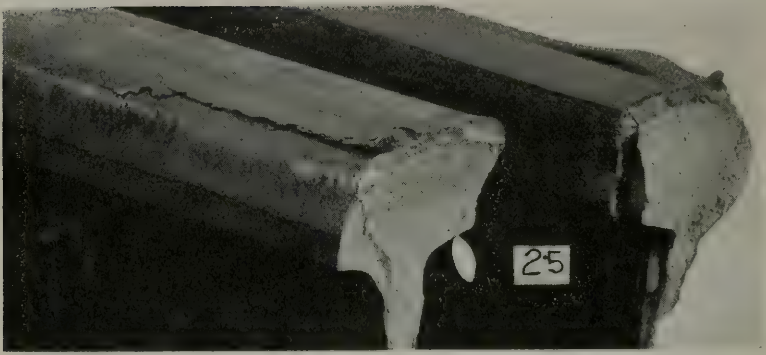

FIG. 74. RAIL 25.

(26) SPLIT HEAD.

85-lb. P. S. Bessemer, made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 4636; laid in May, 1909, on low rail of one-degree two-min. curve, gravel ballast; removed on November 23, 1909.

C .771; Mn 1.00; P .133; Si .082; T. S. 72,490 lbs. per sq. in.; E. L. 72,490 lbs. per sq. in.; Elong. in 2 in., 0.00%; Red. area 0.00%.

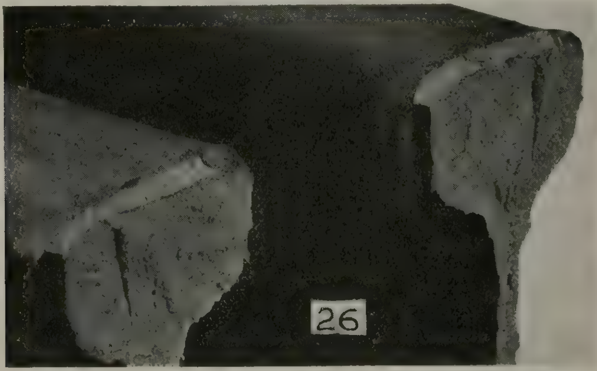

FIG. 75. RAIL 26.

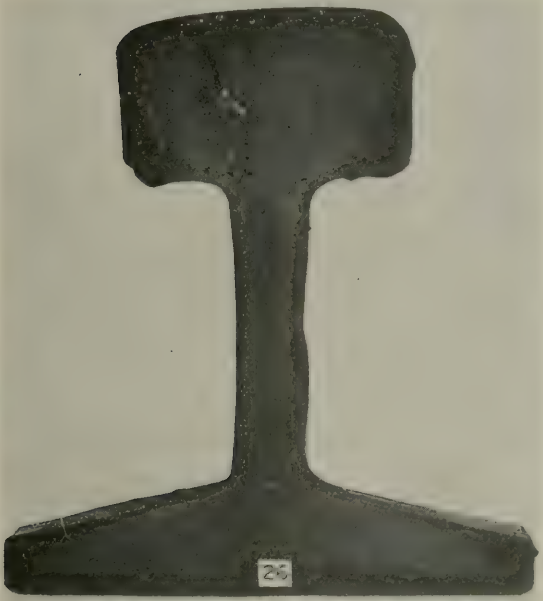

FIG. 76. RAIL 26.

(27) SPLIT HEAD.

85-lb. P. S. Bessemer, made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 4629; laid May, 1909, on low rail of one-degree one-min. curve, gravel ballast; removed November 23, 1909.

C .841; Mn 1.09; P .168; Si .052; T. S. 96,990 lbs. per sq. in.; E. L. 96,990 lbs. per sq. in.; Elong. in 2 in., 1.00%; Red. area 1.98%.

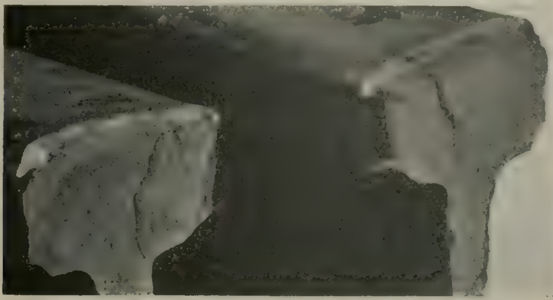

FIG. 77. RAIL 27, CUT 15 FT. 4 IN. FROM END.

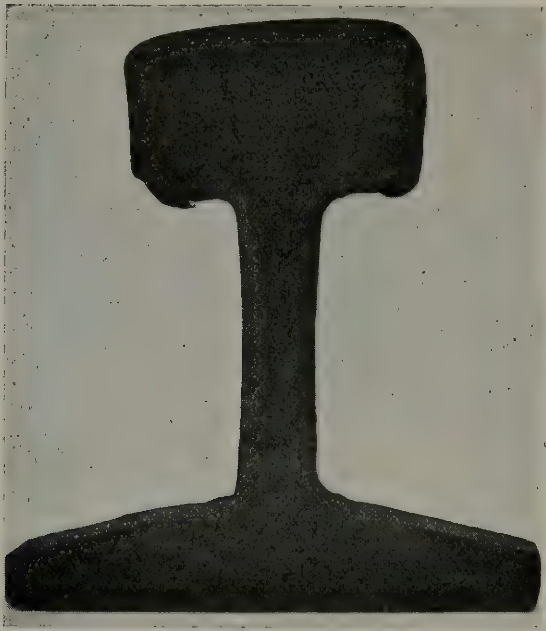

FIG. 78. RAIL 27.

(28) SPLIT HEAD.

85-lb. P. S. Bessemer, made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 1799; laid May, 1909, on low rail of five-degree 22-min. curve, gravel ballast; removed August 7, 1909. The head gave down and began to split for length of six ft.

C .788; Mn .76; P .149; Si .092; S .078; no tensile test made.

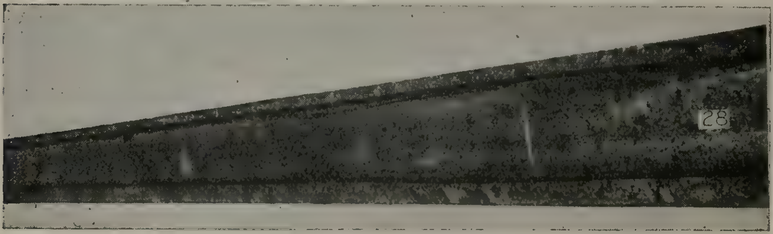

FIG. 79. RAIL 28, TOP OF HEAD.

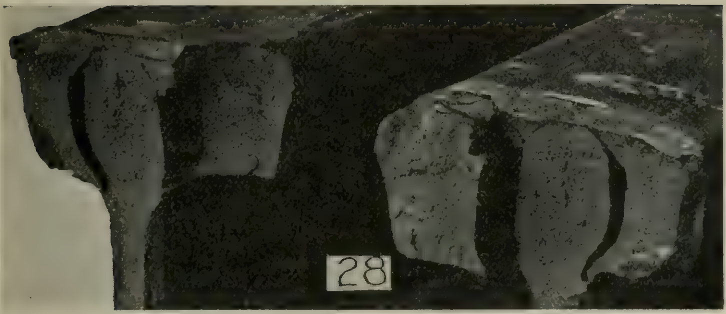

FIG. 80. RAIL 28, CUT 6 FT. 2 IN. FROM END.

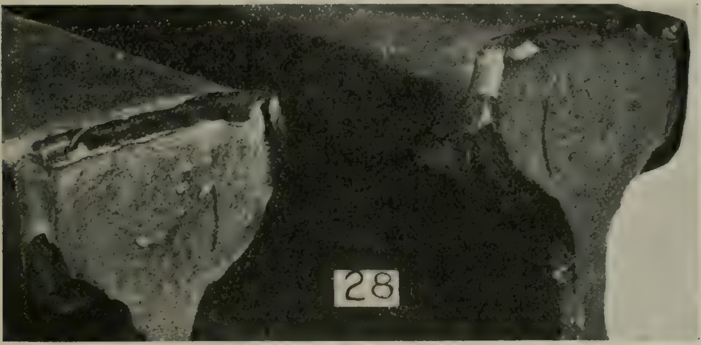

FIG. 81. RAIL 28. CUT 18 FT. FROM END.

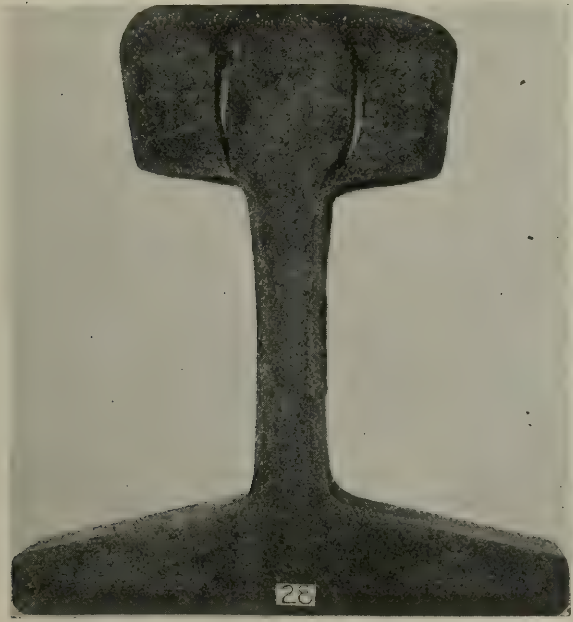

FIG. 82. RAIL 28.

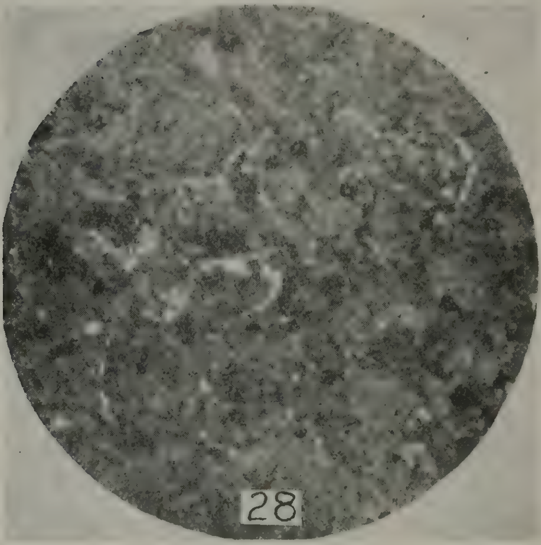

FIG. 83. RAIL 28, CENTER OF HEAD, ETCHED WITH PICRIC ACID—MAGNIFIED 100 DIAMETERS.

(29) SPLIT HEAD.

85-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 1800; laid May, 1909, on low rail of five-degrees 22-min. curve, gravel ballast; removed August 23, 1909.

C .714; Mn .85; P .210; Si .077; S .104! T. S. 124,600 lbs. per sq. in.; E. L. 86,450 lbs. per sq. in.; Elong. in 2 in., 2.00%; Red. area 1.20%.

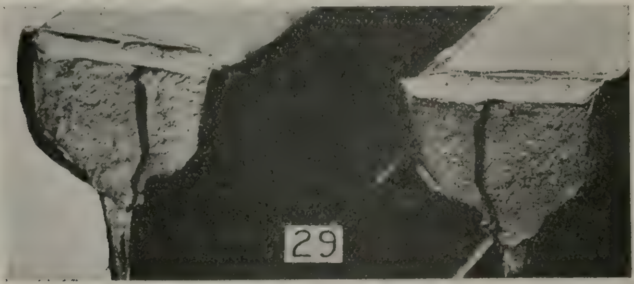

FIG. 84. RAIL 29.

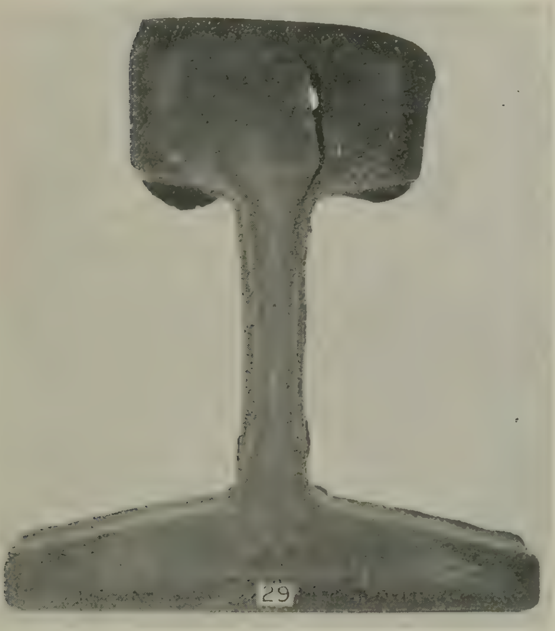

Fig. 85. Rail 29.

(30) SPLIT HEAD.

85-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 4553; laid April, 1909, on low rail of four-degree curve, limestone ballast; removed July 13, 1909. Rail crushed for two ft. six in. starting two ft. from end, same end also has a small crack.

C .807; Mn .96; P .140; Si .087; S .059; T. S. 90,200 lbs. per sq. in.; E. L. 74,200 lbs. per sq. in.; Elong. in 2 in., 1.00%; Red. area 1.48%.

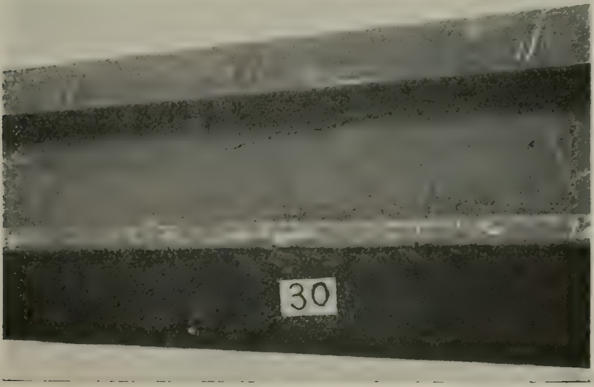

Fig. 86. Rail 30, Note Crack Under Head.

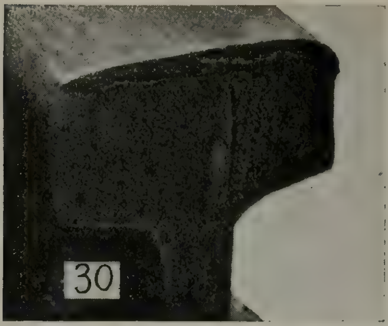

FIG. 87. RAIL 30, END OF RAIL.

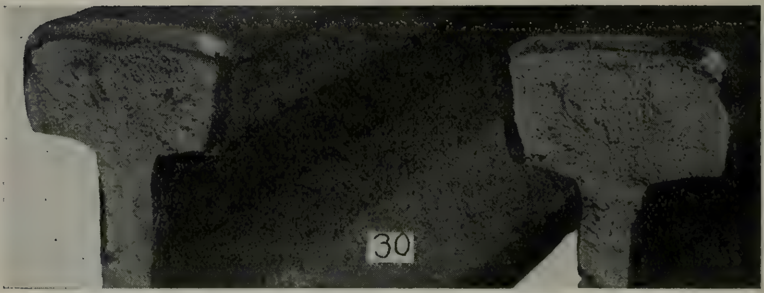

FIG. 88. RAIL 30, CUT 6 FT. FROM RECEIVING END.

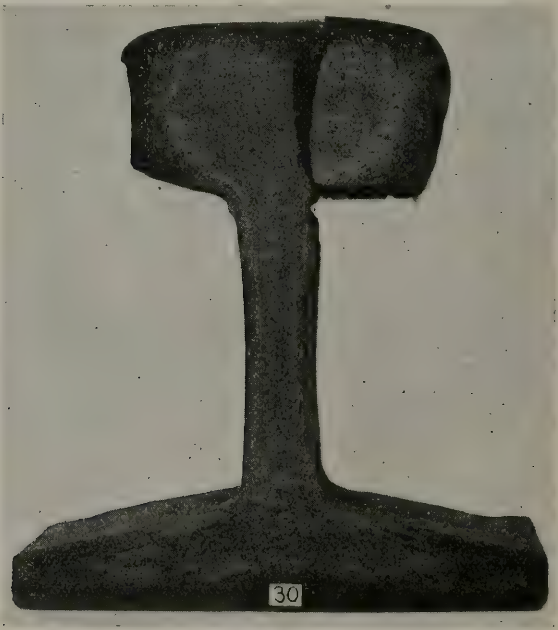

FIG. 89. RAIL 30.

(31) SPLIT HEAD.

85-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 4563; laid April, 1909, on low rail of four-degree curve, limestone ballast; removed July 13, 1909. Split head for distance of twelve ft.

C .734; Mn .93; P .138; Si .089; S .086; T. S. 109,700 lbs. per sq. in.; E. L. 74,500 lbs. per sq. in.; Elong. in 2 in., 2.00%; Red. area 1.94%.

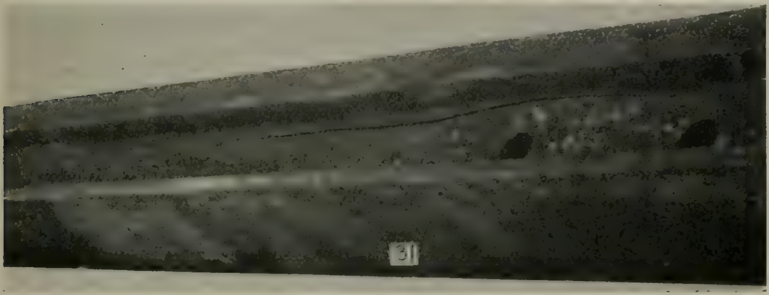

FIG. 90. RAIL 31, SHOWING CRACK UNDER HEAD.

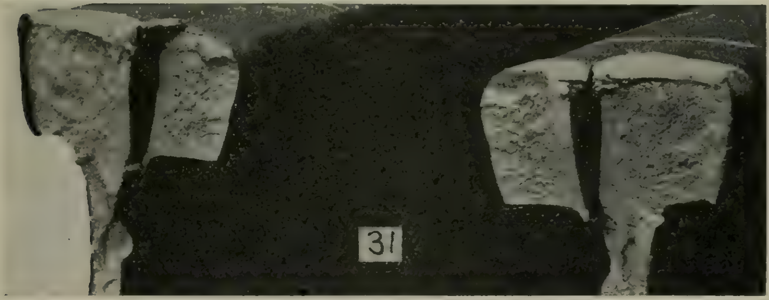

FIG. 91. RAIL 31, CUT 4 FT. 11 IN. FROM RECEIVING END.

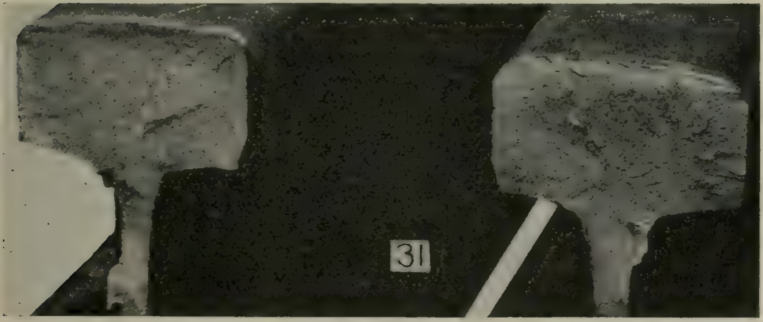

FIG. 92. RAIL 31, CUT 10 FT. 2 IN. FROM RECEIVING END.

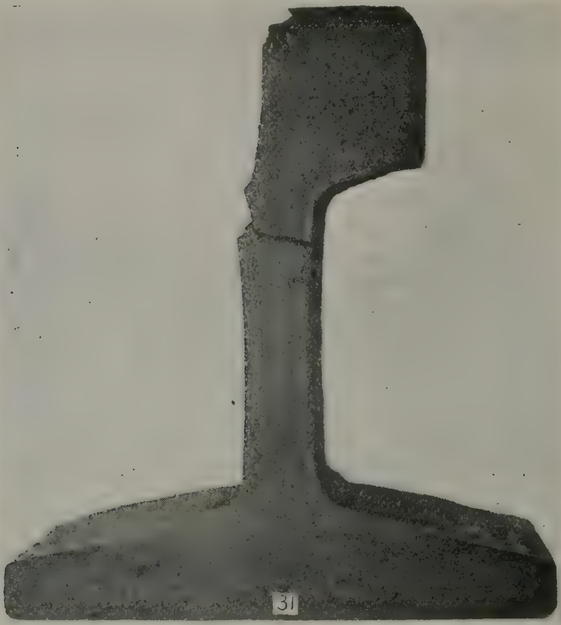

FIG. 93. RAIL 31.

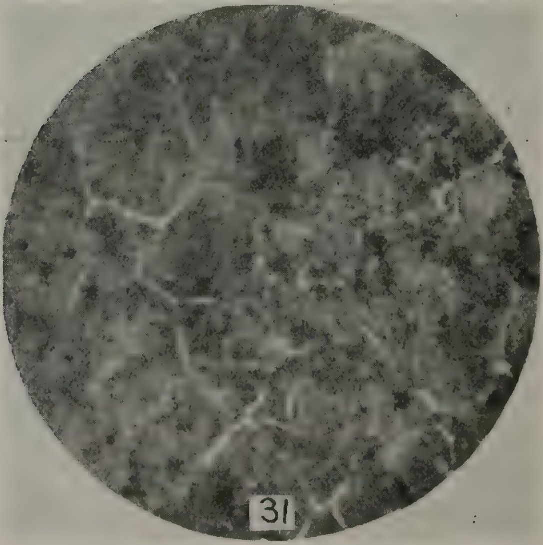

FIG. 94. RAIL 31, CENTER OF HEAD, ETCHED WITH PICRIC ACID—MAGNIFIED 100 DIAMETERS.

(32) SPLIT HEAD.

100-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, February, 1909. Heat No. 2749; laid April, 1909, on two-degree 42-min. curve, stone ballast; removed September 6, 1909. Head crushed for four ft. four in., starting thirty in. from receiving end.

C .616; Mn .80; P .095, .109, .120, .140; Si .129; S .053; T. S. 114,770 lbs. per sq. in.; E. L. 63,560 lbs. per sq. in.; Elong. in 2 in., 11.50%; Red. area 13.55%.

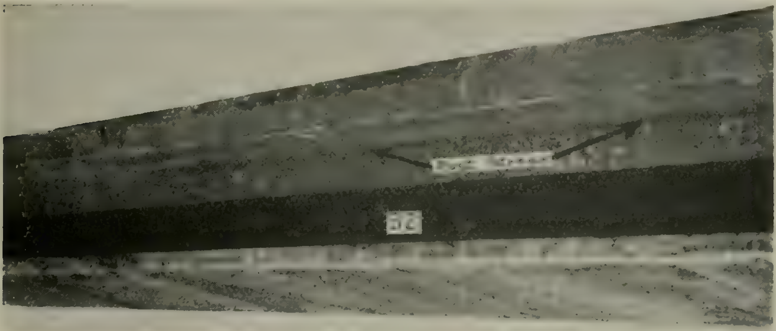

FIG. 95. RAIL 32.

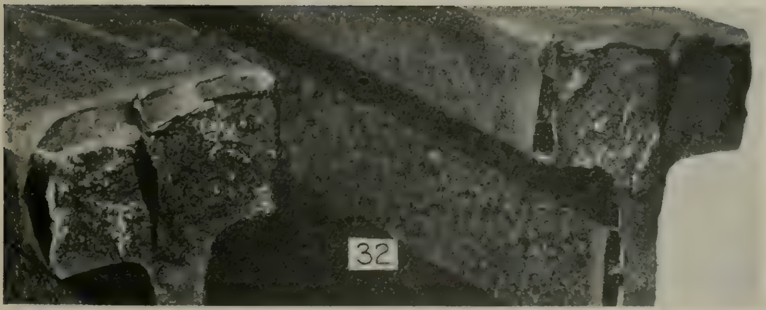

FIG. 96. RAIL 32, CUT 4 FT. 8 IN. FROM RECEIVING END.

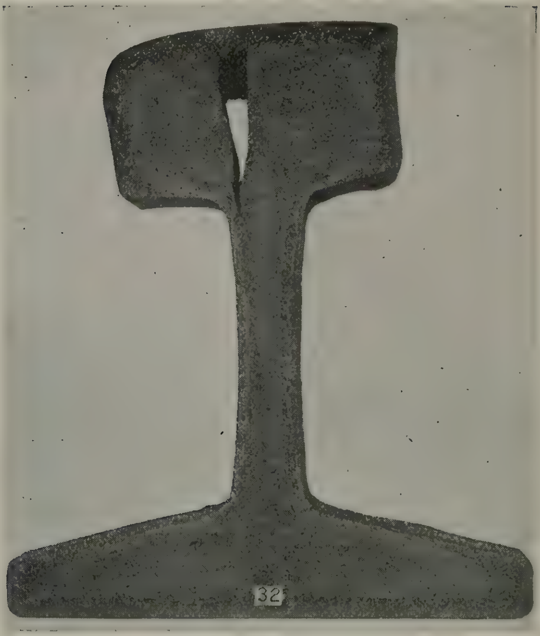

FIG. 97. RAIL 32.

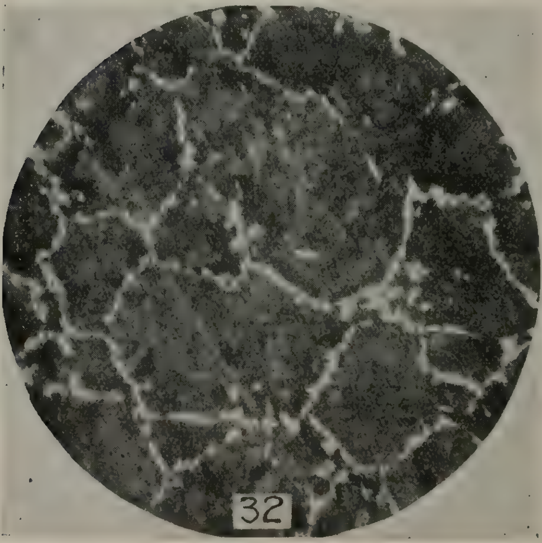

FIG. 98. RAIL 32, CENTER OF HEAD, ETCHED WITH PICRIC ACID—MAGNIFIED 100 DIAMETERS.

(33) SPLIT HEAD.

85-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 4584; laid April, 1909, on low rail of five-degree curve, limestone ballast; removed December 20, 1909, commencing fifteen ft. from receiving end, ball of rail flattened down for a distance of five ft.

C .683; Mn 1.12; P .122; Si .079; T. S. 88,550 lbs. per sq. in.; E. L. 88,550 lbs. per sq. in.; Elong. in 2 in., 1.00%; Red. area 1.22%.

Note.—Specimen broke at fillet.

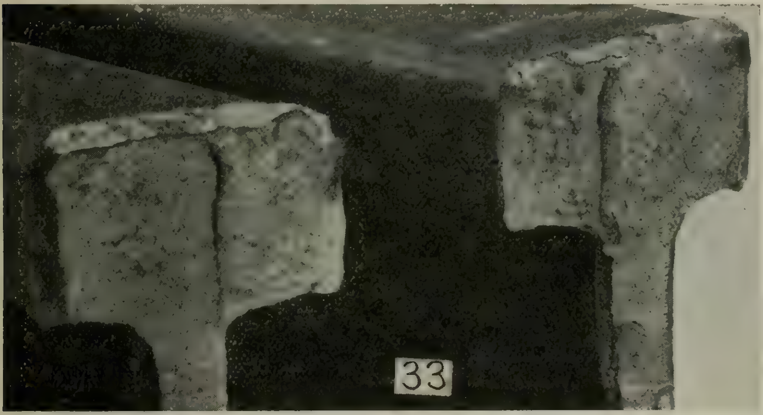

Fig. 99. Rail 33, Cut 12 ft. from Leaving End.

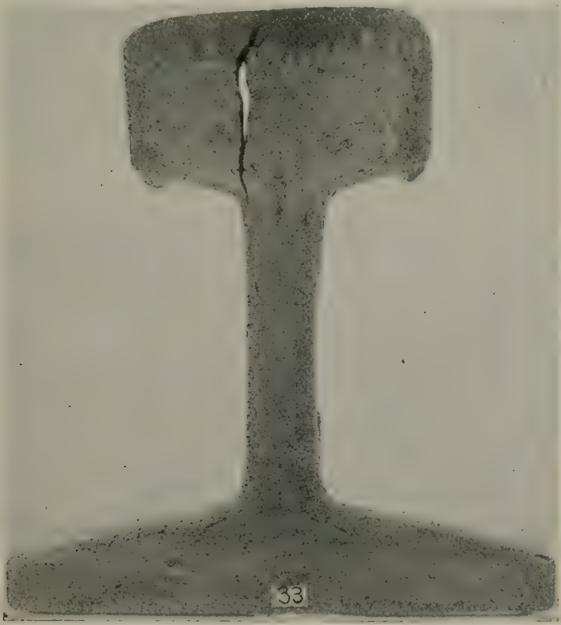

Fig. 100. Rail 33.

(34) SPLIT HEAD.

100-lb. A. R. A.-A., made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 6648; laid May, 1909, on low rail of three-degree 30-min. curve, limestone ballast; removed October 18, 1909. Split head, flaw eight ft. long in ball of rail, one ft. from end; split head accompanied by seam.

C .762, .789, .713; Mn 1.02; P .145; Si .063; T. S. 114,880 lbs. per sq. in.; E. L. 66,460 lbs. per sq. in.; Elong. in 2 in., 10.0%; Red. area 10.94%.

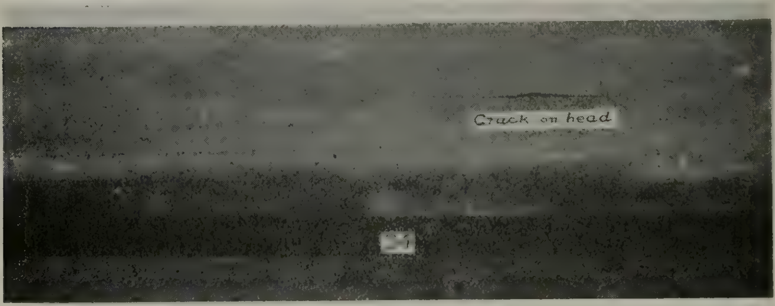

Fig. 101. Rail 34.

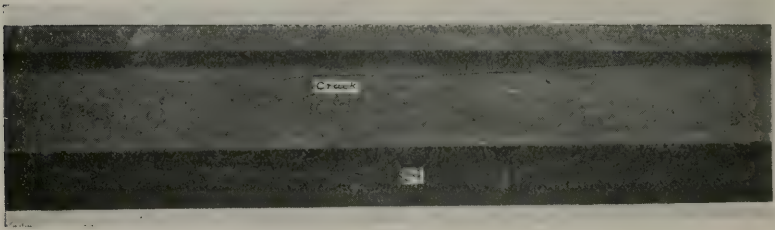

Fig. 102. Rail 34.

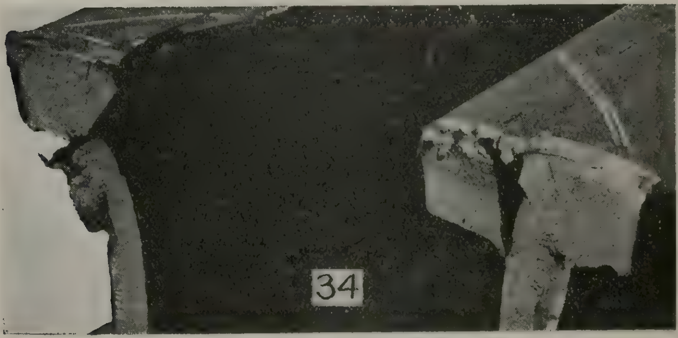

Fig. 103. Rail 34.

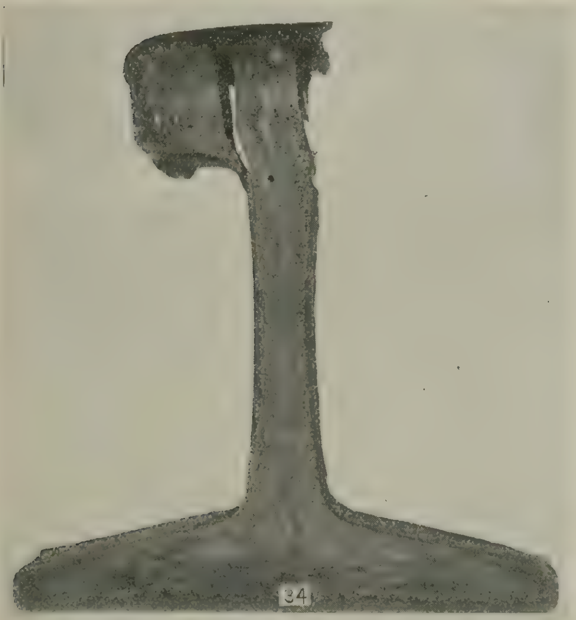

FIG. 104. RAIL 34.

(35) SPLIT HEAD.

100-lb. A. R. A.-A., made by Carnegie Steel Company, Edgar Thomson Works, March, 1909; laid May, 1909, on low rail of three-degree, 30-min. curve, limestone ballast; removed December 21, 1909. Rail split in ball two ft. from end, fifteen ft. long.

C .637; Mn .92; P .118; Si .063; T. S. 117,040 lbs. per sq. in.; E. L. 85,680 lbs. per sq. in.; Elong. in 2 in., 3.50%; Red. area, 3.18%.

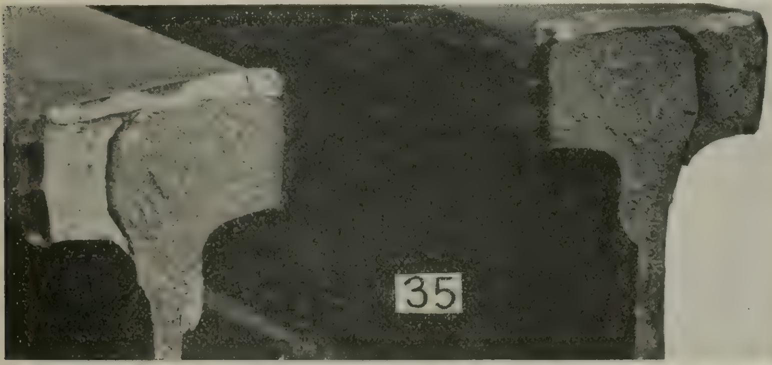

FIG. 105. RAIL 35, CUT 15 FT. FROM RECEIVING END.

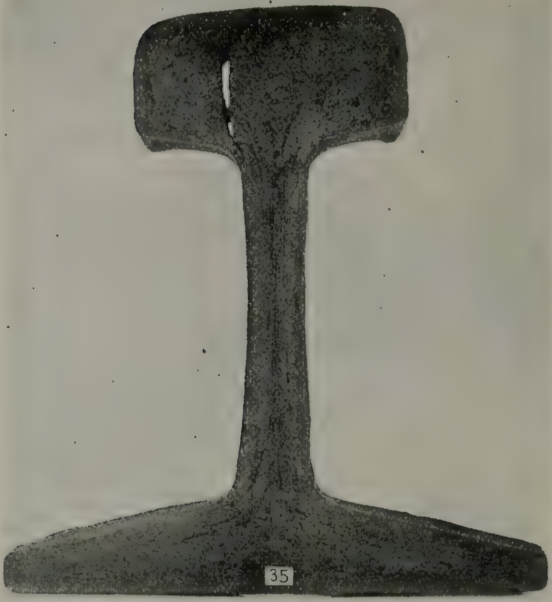

FIG. 106. RAIL 35.

(36) SPLIT HEAD.

100-lb. A. R. A.-A., made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 6716; laid May, 1909, on straight line, limestone ballast; removed December 21, 1909. Rail split in ball three ft. from end, four ft. long.

C .547; Mn .98; P .108; Si .065; T. S. 102,970 lbs. per sq. in.; E. L. 75,000 lbs. per sq. in.; Elong. in 2 in., 2.50%; Red. area 0.00%.

NOTE.—Specimen broke at fillet.

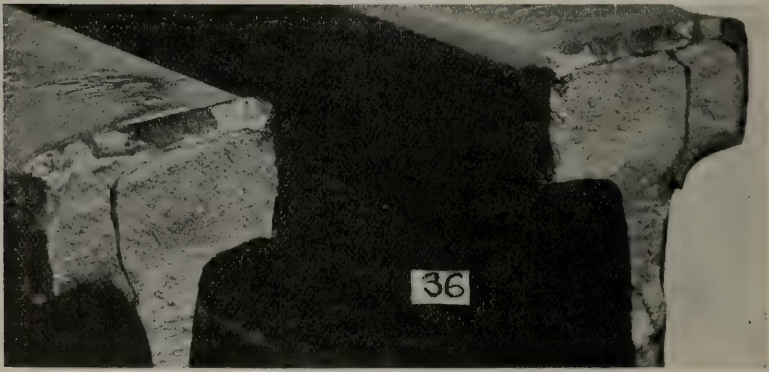

FIG. 107. RAIL 36, CUT 3 FT. 5 IN. FROM RECEIVING END.

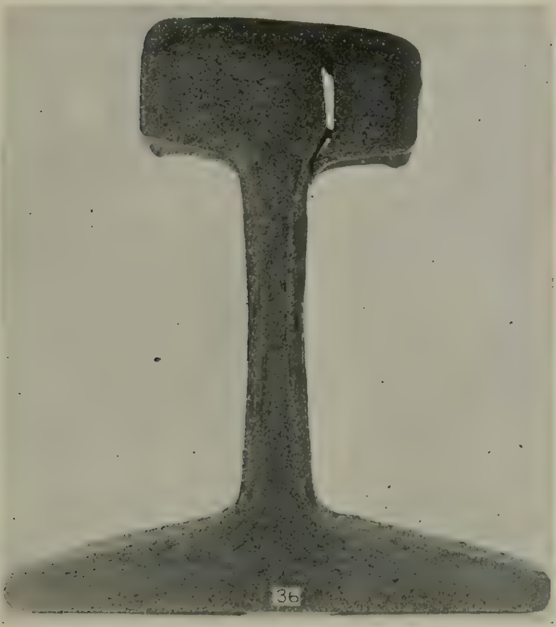

FIG. 108. RAIL 36.

(37) SPLIT HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, Edgar Thomson Works, December, 1895, Heat No. 6919; laid January, 1906, on straight line, gravel ballast; removed October 29, 1909. Three ft. of head split twenty in. from end of rail.

C .537; Mn .86; P .170; Si .080; T. S. 114,210 lbs. per sq. in.; E. L. 60,020 lbs. per sq. in.; Elong. in 2 in., 14.50%; Red. area 22.23%.

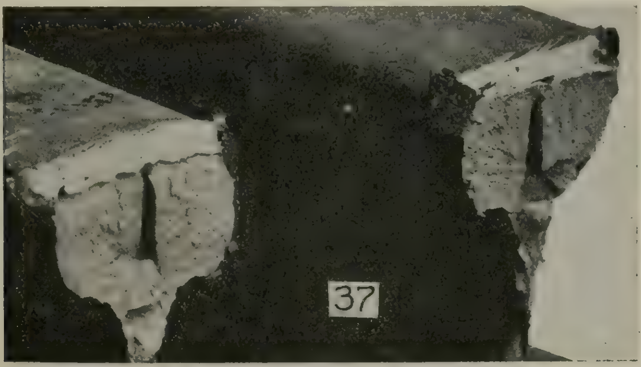

FIG. 109. RAIL 37.

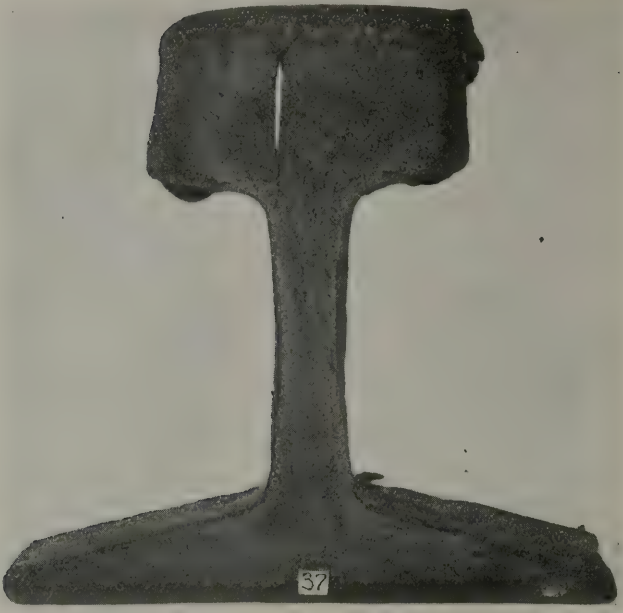

Fig. 110. Rail 37.

(38) SPLIT HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, Edgar Thomson Works, May, 1898, Heat No. 6863; laid May, 1898, on straight line, gravel ballast; removed December 28, 1909. Six ft. of split head four ft. from end of rail.

C .495; Mn .90; P .110; Si .095; T. S. 116,270 lbs. per sq. in.; E. L. 74,130 lbs. per sq. in.; Elong. in 2 in., 7%; Red. area 6.31%.
6.31%.

Note.—Specimen broke in threaded end.

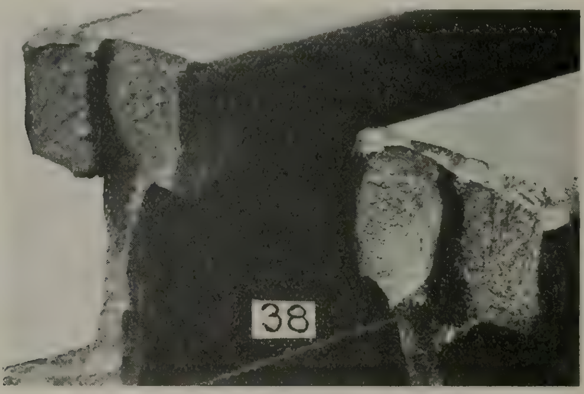

Fig. 111. Rail 38.

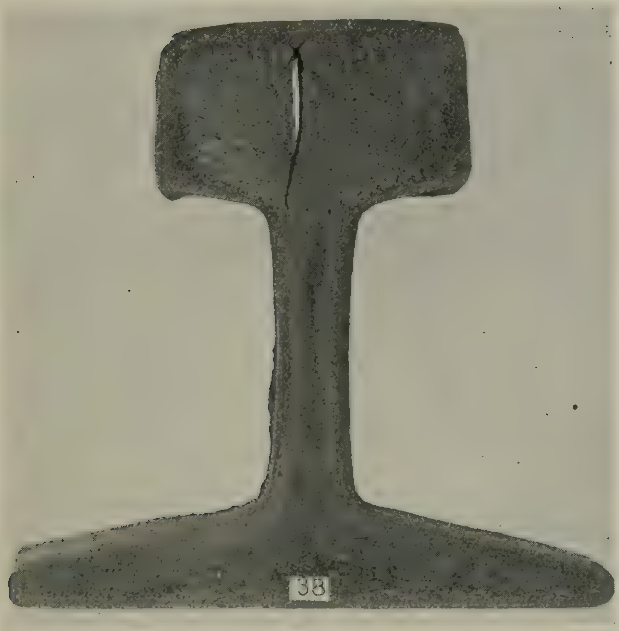

FIG. 112. RAIL 38.

(39) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1899, Heat No. 4959; laid May, 1899, on straight track, gravel ballast; removed October 25, 1909. Six ft. of head split twelve ft. from leaving end.

C .647, .733, .648; Mn 1.00; P .151, .126, .155; Si .197; T. S. 118,610 lbs. per sq. in.; E. L. 72,490 lbs. per sq. in.; Elong. in 2 in., 13.0%; Red. 15.03%.

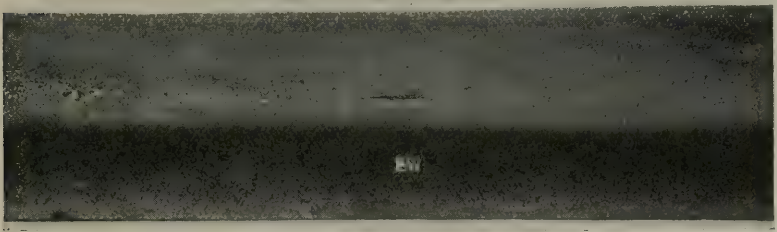

FIG. 113. RAIL 39, SHOWING TOP OF HEAD.

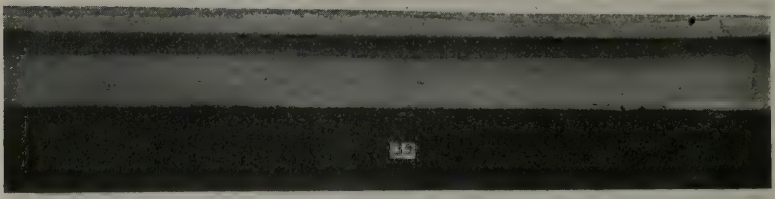

FIG. 114. RAIL 39, SHOWING CRACK UNDER HEAD.

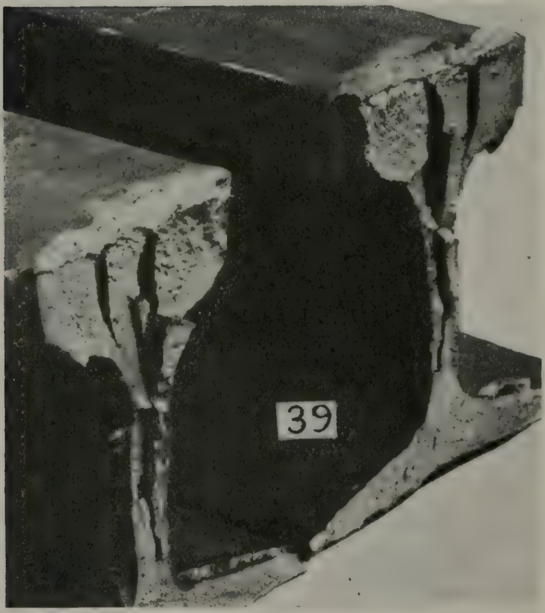

FIG. 115. RAIL 39.

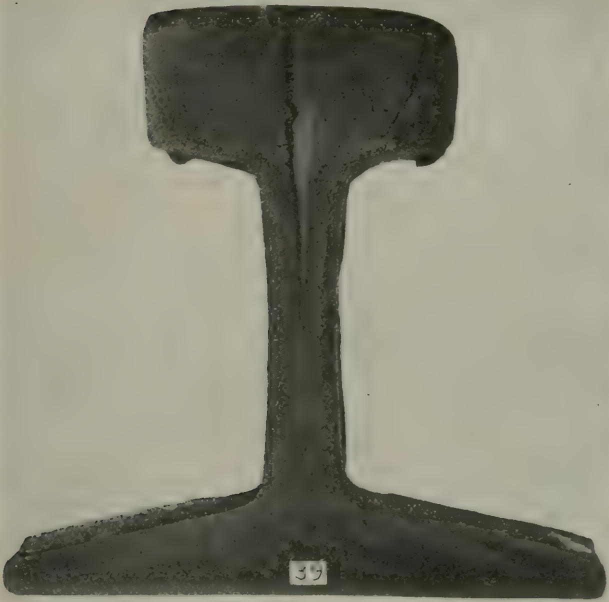

Fig. 116. Rail 39.

(40) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, October, 1902, Heat No. 2583; laid October, 1902, on straight line, gravel ballast; removed December 1, 1909. Rail was split on ball three ft. from the end. The cap of rail was bulging up.

C .293; Mn .89; P .098; Si .162; T. S. 108,340 lbs. per sq. in.; E. L. 92,860 lbs. per sq. in.; Elong. in 2 in., 14%; Red. area 16.17%.

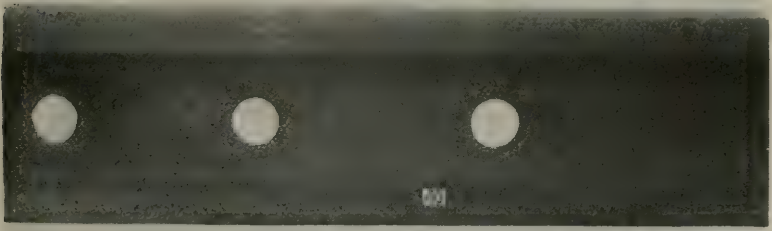

Fig. 117. Rail 40.

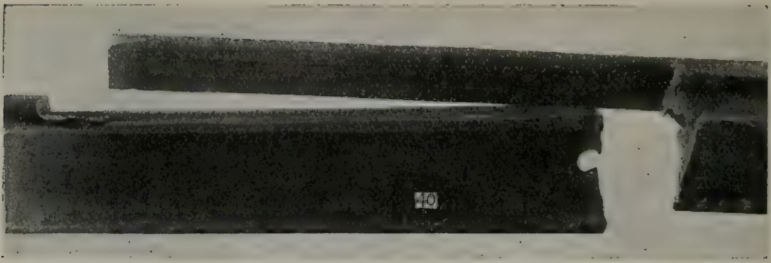

FIG. 118. RAIL 40.

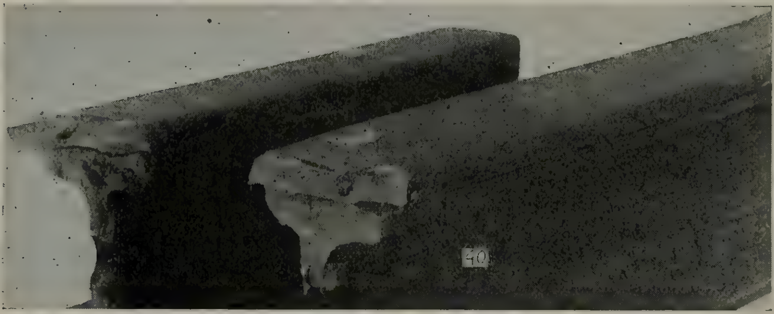

FIG. 119. RAIL 40.

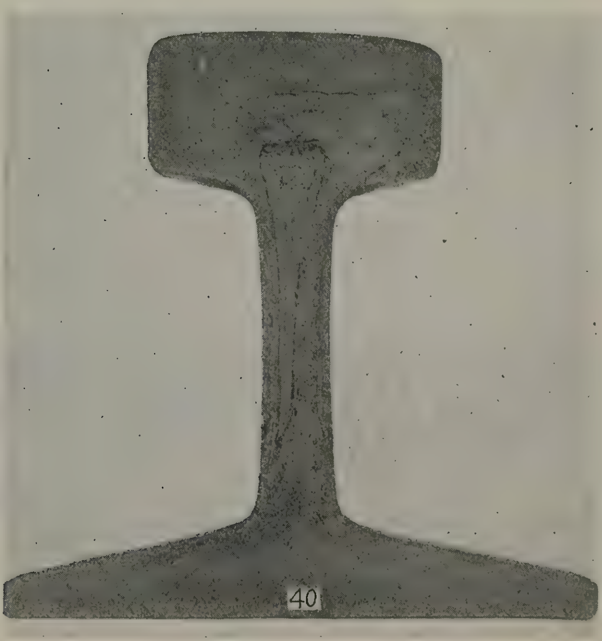

FIG. 120. RAIL 40.

Chicago, January, 1911.
962 Monadnock Block.

A STUDY OF SIXTY-EIGHT FAILED RAILS.

By W. C. Cushing, Chief Engineer, Maintenance of Way,
Pennsylvania Lines West of Pittsburgh, Southwest System, Pittsburgh, Pa

With Discussion by

M. H. Wickhorst, Engineer of Tests, Rail Committee.

Report No. 12 covered a study of forty failed rails and this report deals with a continuation of the same work, covering a study of sixty-eight additional rails which failed on the Southwest System of the Pennsylvania Lines west of Pittsburgh, except a few which failed on the Rock Island System. Mr. Cushing presented his file to the Committee on Rail, together with tabulated statements of the main results and a discussion of the failures, dated September 13, 1910. The file was then edited for publication as this report by Wickhorst, who also presents some discussion. The reports of the individual rails consist in general of the following:

1. A statement of the track condition.
2. General photographs of the failure.
3. Photograph of an etched section.
4. Chemical analysis from interior of head.
5. Physical test from interior of head.

The laboratory tests were made by R. W. Hunt & Co., except in the case of the Rock Island rails, which tests were made by the Rock Island laboratory. The summaries of the main results are shown in tables 3, 4 and 5. (It should be remarked that the numbers of the figures and tables in this report are continued from report No. 12.)

DISCUSSION BY CUSHING.

BROKEN RAILS.

(1) In this study there are thirteen broken rails, eight of which are A. S. C. E. section, four P. S., and one unknown. Only three of these breakages occurred at the joint, and it is not known that the joint had anything to do with them, as other causes were sufficient to bring

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Report No. 13, January, 1911.

TABLE 3.

No.	Sec. No.	Weight of Rail lbs. per Yard	Rail Section	Manufacturer	Year of Rolling	Bessemer or Open Hearth	Position in Ingot	Kind of Failures	Chemical Analysis of Rail					Tensile Strength	Elastic Limit	Elongation per cent	Reduction of Area per cent of original section.	Fracture	Cause of Failure	No.
									C.	Mn.	P.	Si.	S.	lbs. per sq. inch.		in 2 ins.				
43	1	100	A.S.C.E.	Carnegie	1902	B.		Broken	.666	1.38	.077 .094	.144		122190	78530	14.00	16.51	Gran.	Hard & possibly injured in straightening	43
44	3	85.	"	"	1903	"		"	.530	.78	.106	.079							Somewhat unsound. At Joint.	44
45	33	100	"	"	1905	"		"	.570	1.26	.090	.114		131190	86040	4.50	2.81	Cryst.	Hard & brittle.	45
46	40	85	8504	Illinois	"	"		"	.498 .510	.71 .84	.051 .067	.14 .19	.049 .054	116450	88200	15.00	21.20	"	Unknown Rock Island	46
47	367	"	A.S.C.E.	Lorain	"	"		"	.444 .525	.88 .99	.089 .110	.050 .070	.058 .060	98980	67061	12.50	19.90	"	" " "	47
48	53	"	"	Car.	1906	"		"	.693	1.00	.100	.097		133990	71200	.12	6.41	Gran.	Unsound, brittle, hard & segregated.	48
49	17	100	"	"	"	"		"	.704	1.13	.084	.125		127670	78230	14.00	21.61	"	Hard.	49
50	34	"	"	"	"	"		"	.613	1.29	.085	.062		123210	66620	16.50	24.70	"	Considerable hardness.	50
51	203	85	"	"	"	"		"	.601	1.04	.077	.128		124800	81130	14.00	17.23	"	Crack from lap in base during rolling.	51
52	31	100	P.S.	"	1909	"	B.	"	.642	.91	.097	.107		116970	75150	5.00	4.75	"	Brittle and somewhat hard. At Joints.	52
53	7	"	"	"	"	"	"	"	.567	.90	.111	.079		118850	69280	15.00	21.49	"	Probably injured in straightening. At Joint	53
54	3	85	"	Ill's.	"	"	C.	"	.502	.90	.085	.144		111010	73460	21.50	34.03	70% Gran.	Possibly injured in straightening.	54
55	102	"	"	Car.	1910	"	A.	"	.584	.95	.095	.154		58550	58550	0.00	0.00	Gran.	Brittle and unsound.	55
56	29	85	P.R.R.	Carnegie	1898	B.		Flow of Metal	.412	.69	.090	.102		90120	60370	22.00	38.81	Silky	Very soft steel	56
57	19	85	P.R.R.	Carnegie	1895	B.		Split Head	.674	1.02	.165	.030		92280	92280	1.00	.82	Gran.	Brittle, Unsound and Segregated	57
58	2	"	"	"	"	"		" "	.632	.92	.161	.92	.093	118350	71570	5.00	5.57	Cryst.	" " " "	58
59	43	"	"	"	"	"		" "	.540	.71	.132	.100		97740	55900	8.50	8.62	Gran.	Rather high Phos., Unsound & somewhat Brittle.	59
60	43	"	"	"	"	"		" "	.512	.90	.097	.093		107080	72440	16.00	22.87	"	Unsound.	60
61	47	"	"	"	1898	"		" "	.627	.86	.175	.163		113190	97640	.06	3.18	Cryst.	Brittle, Unsound and Segregated.	61
62	47	"	"	"	"	"		" "	.567	.86	.144	.093		107150	67690	7.00	8.01	Gran.	Rather high Phos. Unsound & somewhat Brittle.	62
63	33	"	"	"	"	"		" "	.595	.83	.120	.149		116450	72440	15.00	20.07	"	Unsound and Segregated.	63
64	33	"	"	"	"	"		" "	.531	.71	.118	.102		105470	65640	18.00	26.12	30% Gran	Unsound.	64
65	1	"	A.S.C.E.	"	1899	"		" "	.612	.97	.089	.146		109410	82210	2.50	2.81	Gran.	Brittle, Unsound and Segregated	65
66	1	"	"	"	"	"		" "	.605	.95	.105	.121		97910	73150	3.00	0.00	Cryst.	" " " "	66
67	1	"	"	"	"	"		" "	.593	1.05	.098	.149		106270	82420	3.50	4.33	Gran.	Brittle and Unsound.	67

TABLE 4.

No.	Sec. No.	Weight of Rail lbs. per Yard	Rail Section	Manufacturer	Year of Rolling	Bessemer or Open Hearth	Position in Ingot	Kind of Failures	Chemical Analysis of Rails					Physical Test					Cause of Failure	No.
									C.	Mn.	P.	Si.	S.	Tensile Strength lbs. per sq. inch	Elastic Limit lbs. per sq. inch	Elongation per cent in 2 ins.	Reduction of Area per cent of original section	Fracture		
68	80	85	A.S.C.E.	Carnegie	1899	B.		Split Head	.613	.90	.111	.128		74330	74330	1.00	.76	Cryst.	Brittle, Unsound and Segregated.	68
69	9-A.	"	"	"	"	"		" "	.623	.88	.106	.111		122140	77860	5.50	0.00		" " & somewhat Segregated.	69
70	24	"	"	"	1900	"		" "	.545	.91	.124	.102		115130	77710	15.00	18.30	Gran.	Unsound.	70
71	4	"	"	"	1902	"		" "	.505	.63	.096	.042		88660	55490	10.00	12.83	80% Gran.	Unsound and somewhat Brittle	71
72	1	"	"	"	1903	"		" "	.709	80	.194	.037		131980	88140	5.50	4.36	Gran.	Brittle, Unsound & Segregated	72
73	2	"	"	"	"	"		" "	.530	.61	.150	.064		85690	52980	4.00	5.50	"	" " " "	73
74	41	80	"	T.C.&I.	"	O.H		" "	.565 .620	.98 1.08	.063 .095		.020 .023	129880	89270	12.50	16.60	Cryst	Unsound and Segregated R.I	74
75	321	85	"	Lorain	1905	B.		" "	.490 .670	.65 94	.081 .142	.052 057	071 .124	129081	80969	6.25	7.09	"	Unsound, Segregated & somewhat Brittle "	75
76	4	100	"	Illinois	1907	"		" "	.455 .588	88 1.02	.098 .122	.073 .110	.061 .082	115480	62360	12.50	22.50	"	Unsound "	76
77	8	"	P.S.	Cambria	"	"	A.	" "	.607	.97	.116	.095		118120	82140	7.00	7.49	Gran.	Brittle, Unsound & somewhat Segregated.	77
78	8	"	"	"	"	"	E.	" "	.603	1.06	.120	.098		118610	77970	16.50	29.86	"	Hard, " " " "	78
79	27	85	"	Gary	1909	O.H	G.	" "	.682	.69	.047	.130		113200	78260	13.50	16.92	"	Scrap steel from ingot stool rolled in rail	79
80	42	"	"	"	"	"		" "	.737	.75	.031	.111		117170	88280	15.00	22.52	80% Gran.	" " " " " " " "	80
81	42	"	"	"	"	"		" "	.754	.69	.039	.135		129550	78170	14.00	10.17	Gran.	" " " " " " " "	81
82	42	"	"	"	"	"		" "	.685	.74	.034	.167		114770	69590	16.00	22.87	"	" " " " " " " "	82
83	48	"	"	"	"	"	B.	" "	.754	.75	.031	.110		120800	80010	13.50	18.70	70% Gran.	" " " " " " " "	83
84	25	"	"	"	"	"	G.	" "	.813	.70	.022	.082		120380	82270	13.00	18.23	80% Gran.	" " " " " " " "	84
85	25	"	"	"	"	O.H	"	" "	.712	.83	.038	.161		119770	72490	15.50	22.21	60% Gran	" " " " " " " "	85
86	25	"	"	"	"	"	C.	" "	.642	.66	.030	082		105090	57510	18.00	21.49	70% Gran.	" " " " " " " "	86
87	48	"	"	"	"	"	B.	" "	.752	.76	.045	.105		121500	72600	13.00	15.52	Gran.	" " " " " " " "	87
88	40	"	8504	"	"	O.H.	H.	" "	.580 .624	737 .885	.056	.11 .16	.040 .050	124870	77745	15.00	18.3	Cryst.	" " " " " " " -R.I.	88
89	40	"	"	"	"	"	E.	" "	.530 .595	.67 .70	.034 .041	.12	.042 .048	115280	78700	13.50	19.30	"	" " " " " " " " "	89
90	31	100	P.S.	Carnegie	"	B.	B.	" "	.636	.85	.105	.095		102100	67690	3.50	3.22	Gran.	Brittle, Unsound and Segregated	90
91	101	85	"	"	"	"	C.	" "	.771	.94	.133	.068		102030	78840	1.00	1.98	"	" " " "	91
92	101	"	"	"	"	"	G.	" "	.752	.74	.138	.051		107280	80340	3.50	3.16	"	" " " "	92
93	8	100	"	"	"	"	B.	" "	.780	.96	.126	.077		76280	76280	1.00	.82	"	" " " "	93
94	10	"	"	"	"	"	"	" "	.755	.81	.113	.056		88550	82290	1.00	0.00	"	" " " "	94

TABLE 5.

No	Sec. No	Weight of Rail lbs. per Yard	Rail Section	Manufacturer	Year of Rolling	Bessemer or Open Hearth	Position in Ingot	Kind of Failures	Chemical Analysis of Rails					Physical Test					Cause of Failure	No.
									C.	Mn.	P.	Si.	S.	Tensile Strength lbs. per sq. inch	Elastic Limit lbs. per sq. inch	Elongation per cent in 2 ins.	Reduction of Area per cent of original section	Fracture		
95	31	100	P.S	Carnegie	1909	B.	B.	Split Head	.576	.71	.099	.096		84200	70350	2.00	2.40	Gran.	Unsound and Brittle.	95
96	K	85	"	Illinois	"	"	A	" "	.557	.74	.127	.135		107100	56150	21.00	32.92	30% Gran.	Unsound and somewhat Segregated.	96
97	12	100	"	Car.	"	B.	B.	" "	.712	.98	.108	.870		128170	86250	13.00	17.59	Gran.	Hard, Unsound and Segregated.	97
98	44	"	A.R.A-A.	"	"	"	"	" "	.888	.98	.126	.089		87220	86810	.50	.41	"	Brittle, " " "	98
99	44	"	"	"	"	"	"	" "	.766	1.02	.143	.065		89100	89100	0.00	.76	"	" " " "	99
100	44	"	"	"	"	"	"	" "	.644	1.00	.106	.061		116560	77640	3.00	3.92	"	" " " "	100
101	16	"	"	"	"	"	"	" "	.864	1.01	.157	.105		107360	78730	1.50	2.40	"	" " " "	101
102	8	"	"	"	"	"	"	" "	.540	.94	.095	.072		102090	70450	4.50	5.50	Cryst.	Brittle and Unsound.	102
103	7	85	P.S.	"	1910	"	C.	" "	.475	80	.088	.128		102250	53270	22.50	37.98	Gran.	Incorporation of Foreign Material.	103
104	25	100	P.S.	Cambria	1910	B.	D.	Split Web	.566	.88	.093	.072		117840	74590	17.00	26.43	Gran.	May have been caused by driving bond plug.	104
105	28	85	"	"	1909	"	C.	" "	.517	.97	.097	.098		114010	76460	18.50	30.11	"	Possibly rough handling. At Joint.	105
106	11	"	"	Carnegie	1910	"	A.	" "	.680	1.07	.114	.128		117830	78600	3.50	3.57	Cryst.	Brittle and Segregated. " "	106
107	11	"	"	"	"	"	B.	" "	.637	1.07	.083	.119		109830	86040	5.00	5.09	"	Brittle, Hard & Unsound. " "	107
108	53	100	"	"	1909	"A" O.H.	E.	" "	.623	.63	.034	.121		124810	79780	11.50	16.81	Gran.	Unknown.	108
109	32	85	A.S.C.E.	Car.	1901	B.		Broken Base	.542	.74	.111	.075		105420	65130	7.00	9.00	Gran.	Unsound and Brittle.	109
110	34	"	P.S.	Gary	1909	"B" O.H.		" "	.602	.69	.032	.098		102520	65860	20.50	28.54	40% Gran.	Scrap Steel from Ingot Stool rolled in Rail.	110

about the result, except that the cause in No. 53, "probably injured in straightening," is only supposititious.

(2) Three of them, 43, 53 and 54, were possibly injured in straightening, the first A. S. C. E. section, and the last two P. S. No. 53 shows evidence of such injury, while No. 43 was hard, having 0.666 carbon and 1.38 Mn.

(3) Nos. 44, 48 and 45 were unsound, and No. 55 in addition very brittle.

(4) Nos. 45, 49, 50 and 52 were brittle and hard. No. 50 caused the wreck of train No. 30 west of Scio, Ohio.

(5) No. 51 was apparently due to a crack in the base from a lap caused by rolling.

(6) The cause of the failures of Nos. 46 and 47 of the Rock Island rails is unknown.

(7) It is to be noted, therefore, that more than half of all these failures were caused by defective metal, unsoundness, brittleness or segregation, or combinations of them.

SPLIT HEADS.

(8) Special attention is called to Nos. 57 to 64, the old P. R. R. section of 85-lb. weight. Four of them were laid in 1895 and four of them in 1898, and they have thus been 15 and 12 years, respectively, in coming to the state where the split head has caused the defect to become so pronounced as to require the removal of the rails, and this, too, in spite of the fact that they are all unsound, nearly all segregated, and more than half of them brittle. Observe in the case of No. 59 that the seam extends clear through the web into the base, proving conclusively that the defect always existed. The web seams also show in No. 60. It might at once be concluded that the long time taken in bringing about the final failure is due to the thick, heavy head of the P. R. R. sections being capable of standing more punishment, even though the material be defective, than the section of thinner head, but, in order to determine whether this was so or not, a number of the earliest examples of A. S. C. E. rails, which failed about the same time, were collected and these are shown in Nos. 65 to 70. They are not quite as old as the others, being of the years 1899 and 1900, but are nearly so. They show precisely the same defects as in the case of the P. R. R. section, viz.: they are brittle, unsound and segregated. Nos. 58 and 69 are from the same division, so that the conditions were practically the same, and Nos. 59 to 67, inclusive, were from the same division.

Nos. 71 to 76 are A. S. C. E. rails of the years 1902 to 1907, being thus a collection of different ages, but the defects which caused the failures are no worse than the previous ones. These, too, are brittle, unsound and segregated, and it is, therefore, uncertain whether or not the heavy head enables the rails to last longer, even when of poor material, although the indications are slightly in favor of that view.

(9) The P. S. section begins with No. 77, and Nos. 77 and 78 were from among the first lot of the new section rolled. The interior defects of No. 77 are just as bad as in all the earlier examples, although great care was exercised during the rolling, and it is believed that they were rolled very much cooler than was ever the case before. Even though an "E" rail, No. 78, was unsound as well as hard and segregated.

(10) Nos. 79 to 89 are examples of the same class of failure as described in the case of 23, 24 and 25 in the report of February, 1910. They are due to the former practice at Gary of throwing scrap material, such as old tie plates, on the stool of the ingot to prevent cutting while pouring. It is understood that this practice has been stopped, but while in vogue it was causing a great many failures, as these eleven cases prove. Nos. 88 and 89 were from the Rock Island Lines.

(11) Nos. 90 to 97, P. S. section, Carnegie Bessemer steel, except one, of the year 1909, are all unsound; all brittle, except 96 and 97; and all segregated except 95. Five of them are "B" rails; one "A" (96); one "C," and one "G." It is to be noted, therefore, that cropping off the "A" rail, or from 25 to 30 per cent., does not remove all of the interior defects.

(12) No.s 98 to 102 are of the A. R. A. A. section, Carnegie Bessemer steel, and are all brittle, unsound and segregated, except that No. 102 is not segregated. Every one of the five is "B" rail, further emphasizing the fact stated in the previous paragraph.

(13) In the case of No. 103 some foreign material was incorporated in the head.

SPLIT WEBS.

(14) The failure of Nos. 104 and 105 may have been caused by rough handling, but there surely was a weakness or the failure would not have occurred.

(15) Nos. 105, 106 and 107 were at the joint, but it is not known to have had anything to do with the failures, as Nos. 106 and 107 had serious defects. Only one of these is an "A" rail.

BROKEN BASE.

(16) There are two cases of broken base, one A. S. C. E. and one P. S., but the latter was caused by rolling scrap steel from the ingot stool into the rail at the Gary mill, as in the case of Nos. 78 to 89. The failure of the former was caused by a seam and the metal was unsound and brittle.

This study is further evidence that the prime cause of rail failures is poor quality of material, as stated in my previous report, and it seems to me that the evidence from an inspection of these photographs is overwhelming.

CONCLUSION.

It is quite clear that the new rail sections, neither the P. S. section with the heavy head, nor the A. R. A. A. section with the thinner head, have yet brought about any improvement in the quality of the metal by reason of better proportionate distribution of the material in the head, web and base, respectively, from the hope that the conditions of rolling would be so improved as to produce sound material.

The defects, it seems to me, must be remedied at the blast furnace, and the changes of improvement must bring about less segregation of the elements and smaller inclusion of gas bubbles and slag, in whatever way the results are to be accomplished, whether it be by more time for the mixing of the elements and the escape of the gas, or in some other way not yet discovered.

DISCUSSION BY WICKHORST.

Supplementing Mr. Cushing's discussion, I give Figs. 121, 122 and 123, which show in graphical form the results given in tables 3, 4 and 5, as regards carbon, phosphorus, manganese, tensile strength and elongation. On these diagrams are indicated the limits for Bessemer steel of carbon, phosphorus and manganese, given in the specifications for steel rails shown in the Proceedings of the American Railway Engineering and Maintenance of Way Association for 1910, part 1, page 254; namely, carbon, .45 per cent. to .55 per cent.; phosphorus not to exceed .10 per cent. and manganese .80 per cent. to 1.10 per cent. No standard has been fixed for elongation, but a line is shown at 12 per cent., as ordinary rail steel will readily give a stretch of 12 per cent. in 2-in. in rail from below the "brittle zone" near the top of the ingot.

Broken Rails.—The thirteen rails classified as "broken" are plotted on Fig. 121. Probably the most noticeable feature on these diagrams is that in 10 cases the carbon is above the upper limit of .55 per cent., in several cases considerably so. The phosphorus is, in general, below the maximum limit of .10 per cent. It is above in only two cases and not seriously so. It would seem, therefore, that taken as a whole, phosphorus has not been a factor in causing these failures. Manganese also is mostly between the required limit and although it is high in about three cases, it likewise would seem not to be a factor in causing the failures as a class. The elongation is low in four cases and in two of them so low that the material must be called "fragile." In eight of the twelve cases where the elongation was determined, the stretch was very good, however, and it would seem that no fault can be found with the material, even with the carbon in general a little high. In the previous lot of failures the breaks occurred mostly near the joint, while in this lot they occurred mostly away from it, but in view of the results of tests it would seem that "broken" rails as a class cannot be attributed primarily to any fault in the manufacture, but rather to some severe and probably abnormal condition of handling or service, although, of course, hard or brittle material breaks down sooner than strong and ductile steel.

Steel Inclusions.—An interesting type of failure was shown by the open-hearth rails, made at Gary, which the reports well show to have been due to inclusions of scrap steel, mostly Bessemer tie plates, put on the bottom of the molds to protect the stools while pouring the steel.

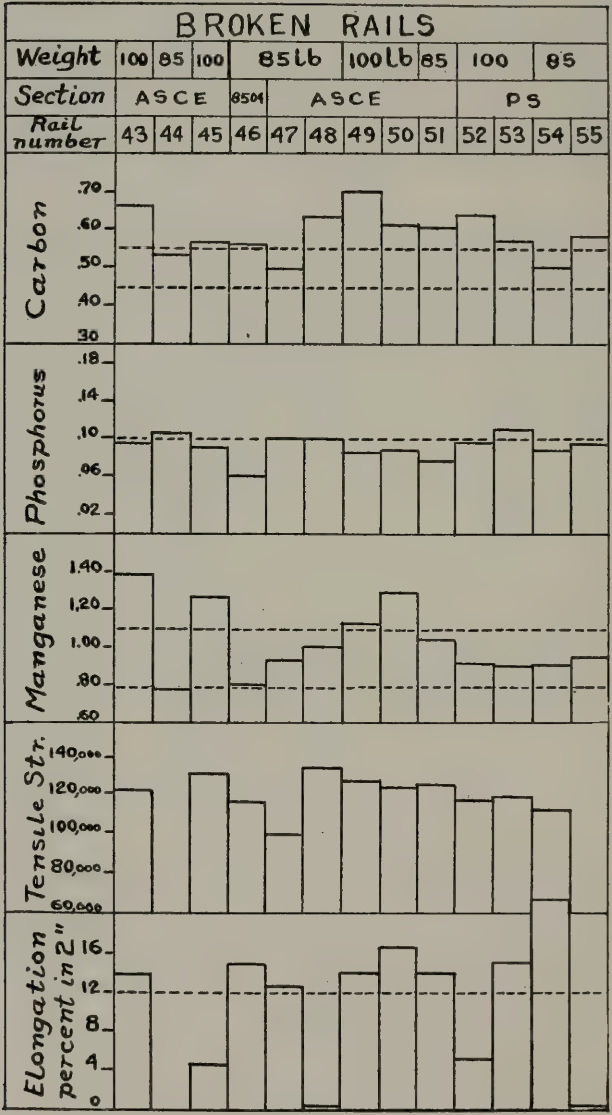
BROKEN RAILS
Weight
100
85
100
85 Lb
100 Lb
85
100
85
Section
ASCE
8504
ASCE
PS
Rail number
43
44
45
46
47
48
49
50
51
52
53
54
55
Carbon
.70
.60
.50
.40
.30
Phosphorus
.18
.14
.10
.06
.02
Manganese
1.40
1.20
1.00
.80
.60
Tensile Str.
140,000
120,000
100,000
80,000
60,000
Elongation percent in 2"
16
12
8
4
0

FIG. 121.

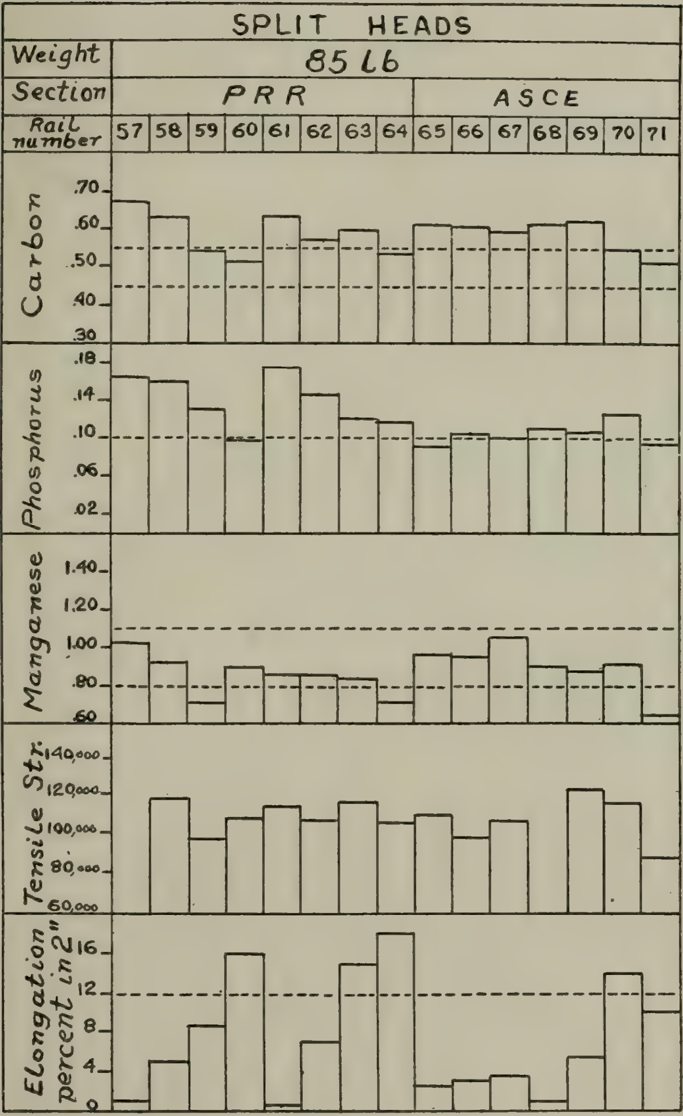
SPLIT HEADS
Weight
85 lb
Section
PRR
ASCE
Rail number
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
Carbon
.70
.60
.50
.40
.30
Phosphorus
.18
.14
.10
.06
.02
Manganese
1.40
1.20
1.00
.80
.60
Tensile Str.
140,000
120,000
100,000
80,000
60,000
Elongation percent in 2"
16
12
8
4
0

FIG. 122.

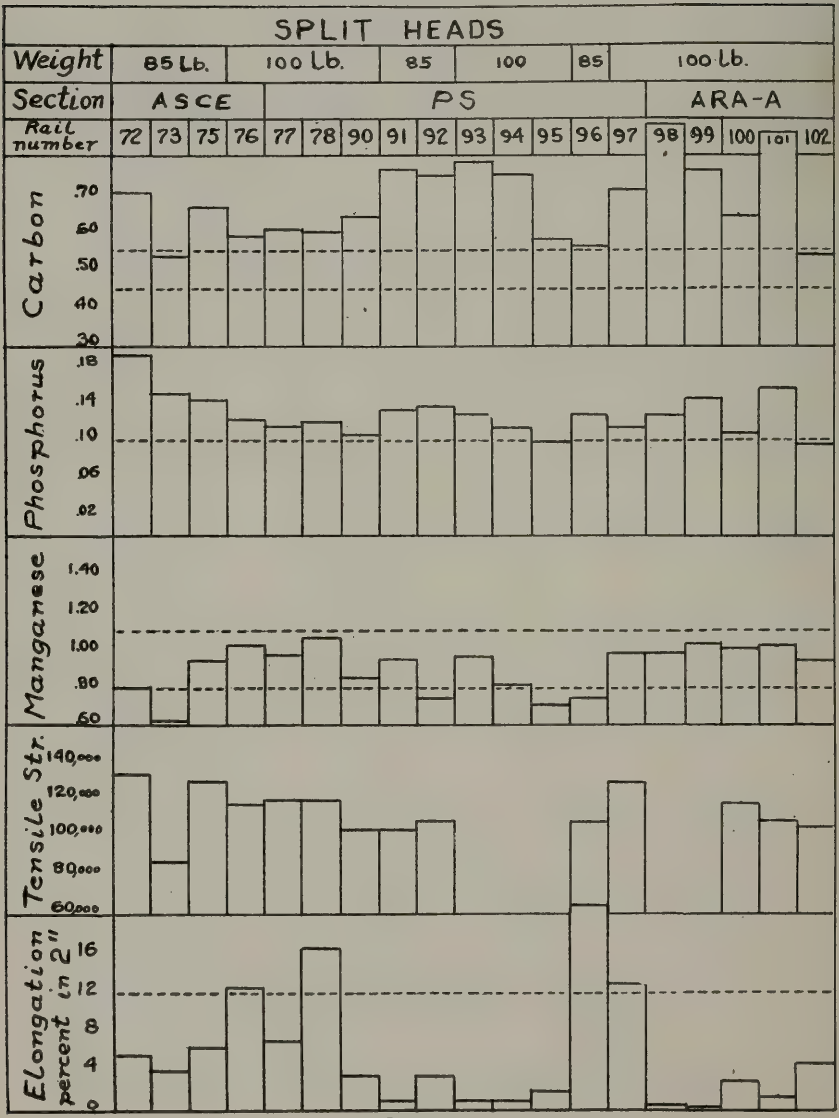
SPLIT HEADS
Weight
85 Lb.
100 Lb.
85
100
85
100 Lb.
Section
ASCE
PS
ARA-A
Rail number
72
73
75
76
77
78
90
91
92
93
94
95
96
97
98
99
100
101
102
Carbon
.70
.60
.50
.40
.30
Phosphorus
.18
.14
.10
.06
.02
Manganese
1.40
1.20
1.00
.80
.60
Tensile Str.
140,000
120,000
100,000
80,000
60,000
Elongation percent in 2″
16
12
8
4
0

FIG. 123.

As this practice has been stopped this type of failure probably has no further interest.

Split Heads.—The failures due to split heads are plotted on Figs. 122 and 123 and include only Bessemer rails, the open-hearth rails that failed, due to steel inclusions, being omitted. These diagrams show strikingly that there is in general an excess of both carbon and phosphorus, in some cases very much so. The manganese in general is very satisfactory and, it would seem, was not a factor in having caused these failures. In about two-thirds of the cases, the ductility, as shown by the elongation, was low, in some of them very low, which would be apt to attend the high carbon and phosphorus. The individual etchings show the rails to be mostly from the upper part of the ingot and the high carbon and phosphorus would, therefore, be due to segregation. Failures due to split heads seem, from this study, to be mostly in rails from the upper part of the ingot, showing segregation of the carbon and phosphorus.

CONCLUSION.

As a result of the study of the 108 failures dealt with in this report and in report No. 12, I think rail failures may be roughly divided in two classes, "broken" rails and "split" rails; the first class including square breaks, angular breaks and perhaps also broken bases, and the second class including split heads and split webs. Broken rails, according this lot of failures and the failures summarized on page 259 of part 1 of the 1910 Proceedings of the American Railway Engineering and Maintenance of Way Association, constitute about 30 per cent., and the split rails about 70 per cent. of all rail failures. The material in about half of the broken rails shows satisfactory on test, while the material in the other half shows more or less defective. This means, it would seem, that poor quality in the rail is a contributary rather than a primary cause for the break.

The split rails generally show segregated material from the upper part of the ingot. In fact, this condition is so frequent that we may say that in general split rails are confined to this kind of material.

REPORTS OF INDIVIDUAL RAILS.

The rest of this report deals with statements and photographs concerning individual rail failures. The following abbreviations are used:

C—Carbon.
P—Phosphorus.
Mn—Manganese.
S—Sulphur.
Si—Silicon.
T. S.—Tensile strength.
E. L.—Elastic limit.
Elong.—Elongation.
Red. area—Reduction of area.

(43) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1902; laid in May, 1902, on straight line, limestone ballast, and removed February 23, 1910. Angular break three ft. four in. from receiving end of rail.

C .666; Mn 1.38; P .094, .088, .084, .077; Si .144; T. S. 122,190 lbs. per sq. in.; E. L. 78,530 lbs. per sq. in.; Elong. in 2 in., 14%; Red. area 16.51%.

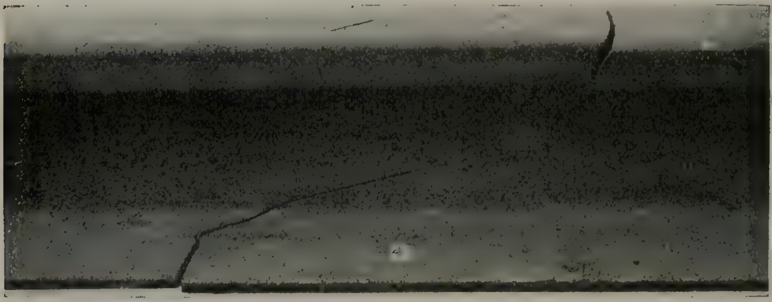

FIG. 124. RAIL 43.

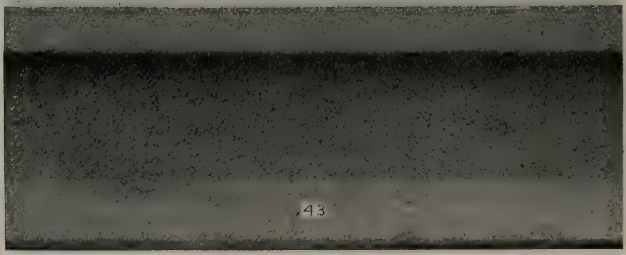

FIG. 125. RAIL 43, CRACK IN WEB, 16 FT. FROM RECEIVING END, EXTENDS ENTIRELY THROUGH WEB.

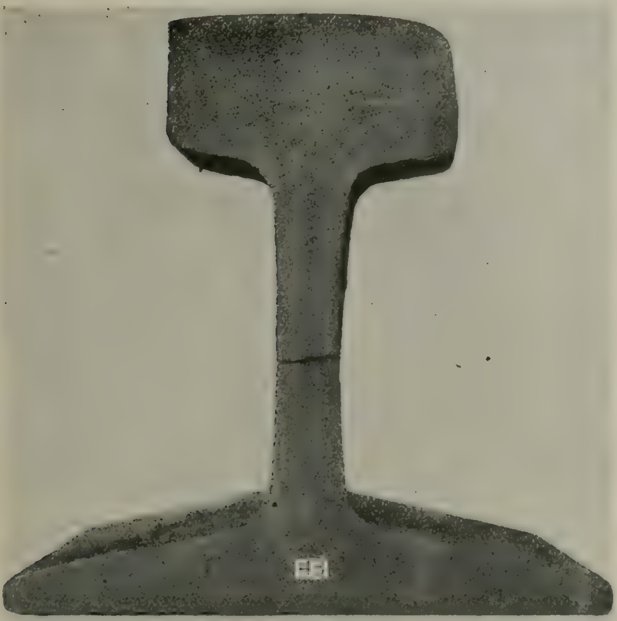

FIG. 126. RAIL 43, ETCHED SECTION.

(44) BROKEN RAIL.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, March, 1903, Heat No. 11163; laid in April, 1903, on straight line, gravel ballast, and removed January 11, 1910. Angular break caused by old flaw in web and base of rail, causing ball to break loose from web; defect hidden by splice.

C .530; Mn .78; P .106; Si .079.

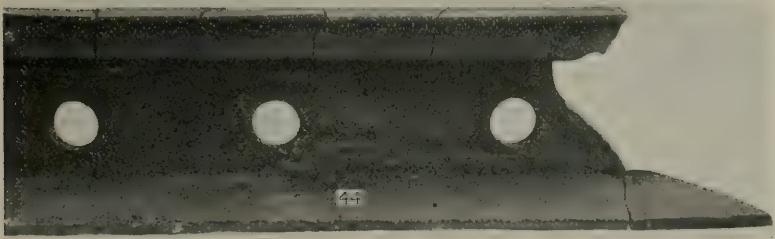

FIG. 127. RAIL 44.

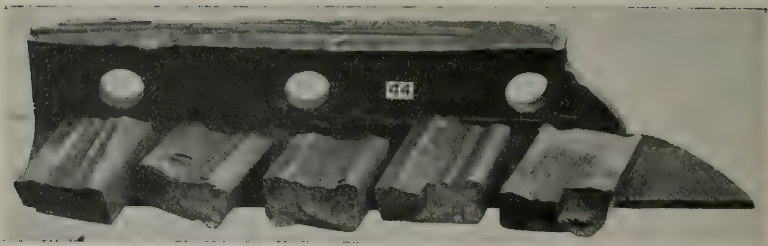

FIG. 128. RAIL 44.

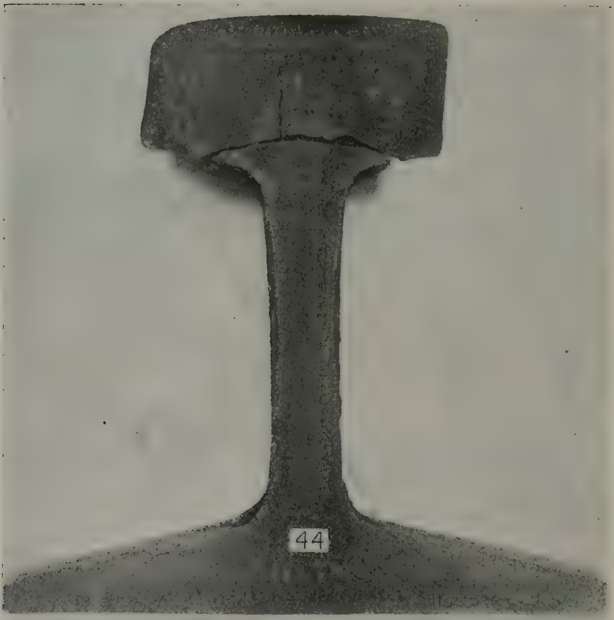

FIG. 129. RAIL 44, ETCHED SECTION.

(45) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, July, 1905; laid in July, 1905, on low rail of one-degree 59-min. curve, stone ballast, and removed November 26, 1909. Square break five ft. seven in. from end.

C .570; Mn 1.26; P .090; Si .114; T. S. 131,190 lbs. per sq. in.; E. L. 86,040 lbs. per sq. in.; Elong. in 2 in., 4.5%; Red. area 2.81%.

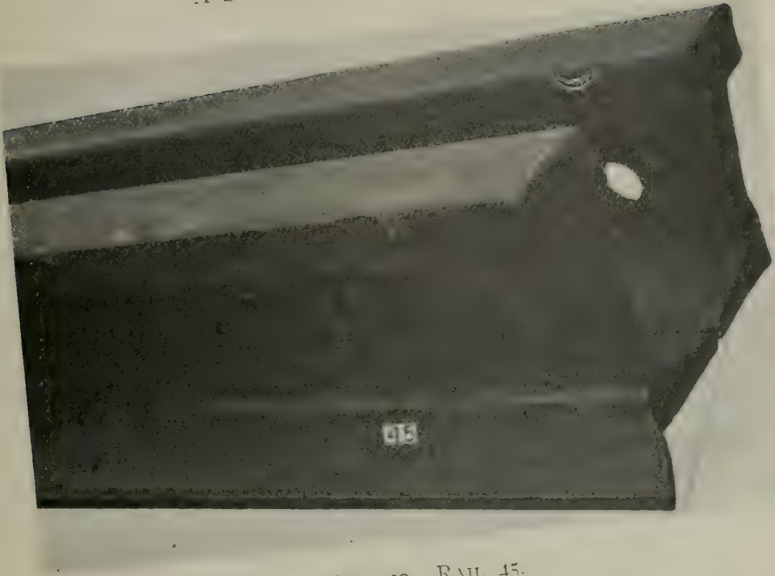

FIG. 130. RAIL 45.

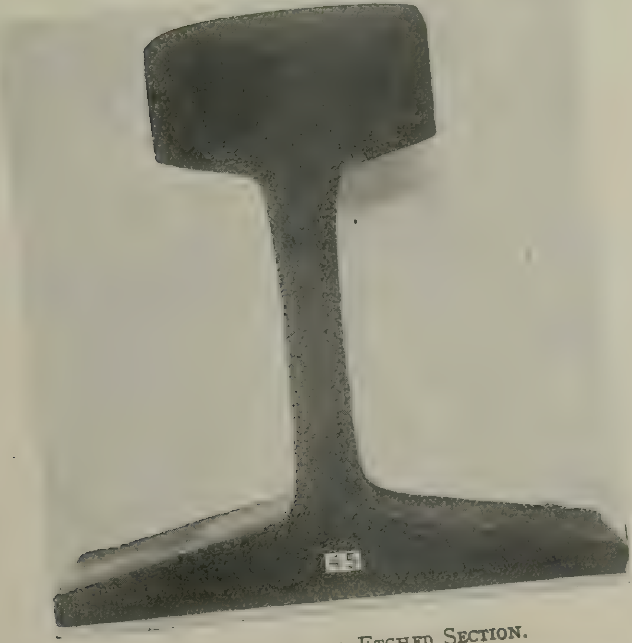

FIG. 131. RAIL 45, ETCHED SECTION.

(46) BROKEN RAIL.

85-lb. 8504, made by Illinois Steel Company, South Works, August, 1905, Heat No. 62062; laid in August, 1905, high rail on three-degree curve, cinder ballast, and removed December 9, 1909. Base and web had been broken for some time, as break was rusty; ball is all that had been holding.

C .510; Mn .710; P .067; S .054; Si .19; T. S. 116,450 lbs. per sq. in.; E. L. 88,200 lbs. per sq. in.; Elong. in 2 in., 15%; Red. area 21.2%.

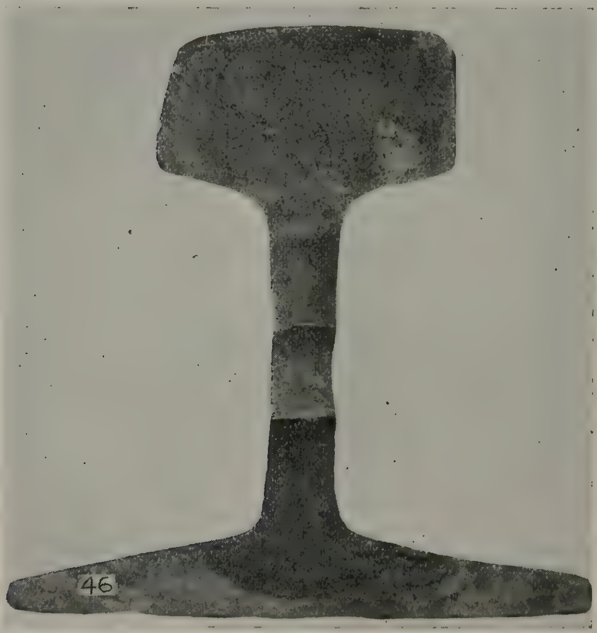

FIG. 132. RAIL 46.

(47) BROKEN RAIL.

85-lb. A. S. C. E., made by Lorain Steel Company, December, 1905; laid in March, 1906, on straight line, ballast of 6 in. of disintegrated granite, and removed February 25, 1909. Rail broke fifteen ft. from end.

C .525; Mn .990; P .089; S .060; Si .070; T. S. 98,980 lbs. per sq. in.; E. L. 67,061 lbs. per sq. in.; Elong. in 2 in., 12.50%; Red. area 19.9%.

(48) BROKEN RAIL.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, July, 1906, Heat No. 5324; laid in May, 1907, on straight line, gravel ballast, and removed January 16, 1910. Angular break; no flaws found at point of break.

C .693; Mn 1.00; P .100; Si .097; T. S. 133,990 lbs. per sq. in.; E. L. 71,200 lbs. per sq. in.; Elong. in 2 in., 6%; Red. area 6.41%.

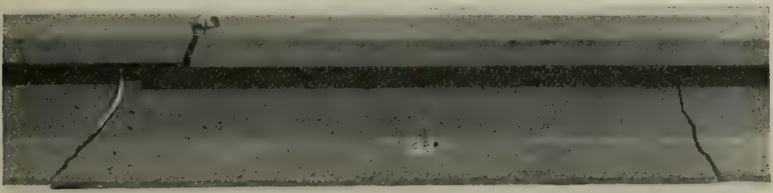

FIG. 133. RAIL 48.

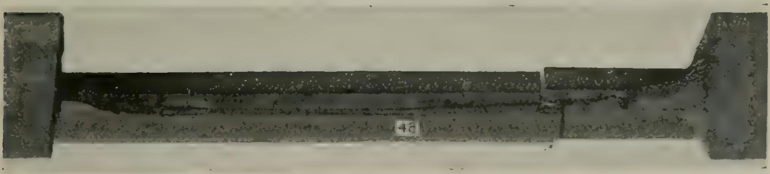

FIG. 134. RAIL 48.

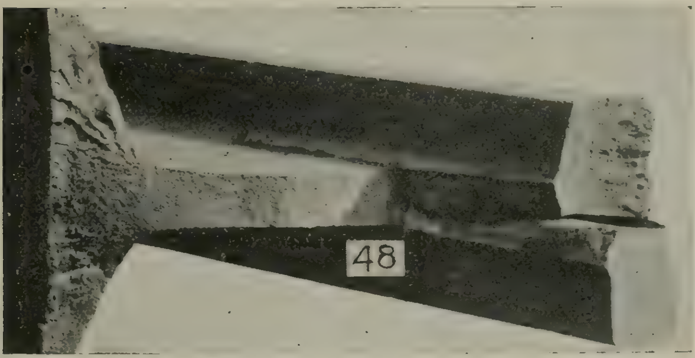

FIG. 135. RAIL 48.

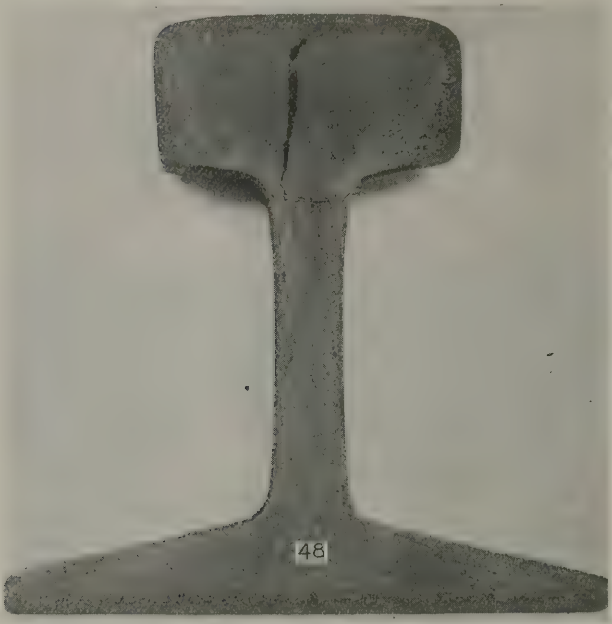

FIG. 136. RAIL 48, ETCHED SECTION.

(49) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, June, 1906; laid in July, 1906, low rail on five-degree 30-min. curve, limestone ballast, and removed February 21, 1910. Square break, 11 ft. 1 in. from end, between ties.

C .704; Mn 1.15; P .084; Si .125; T. S. 127,670 lbs. per sq. in.; E. L. 78,230 lbs. per sq. in.; Elong. in 2 in., 14%; Red. area 21.61%.

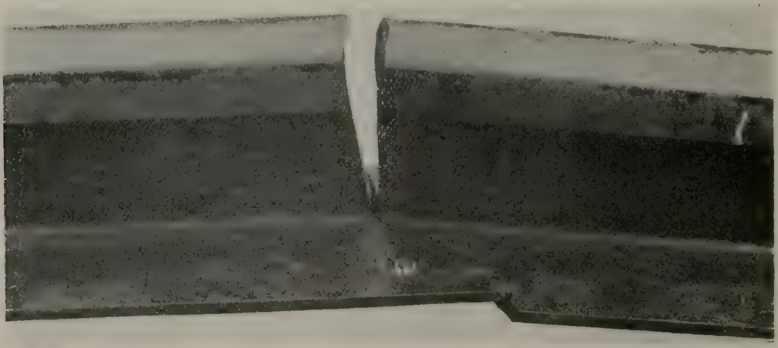

FIG. 137. RAIL 49.

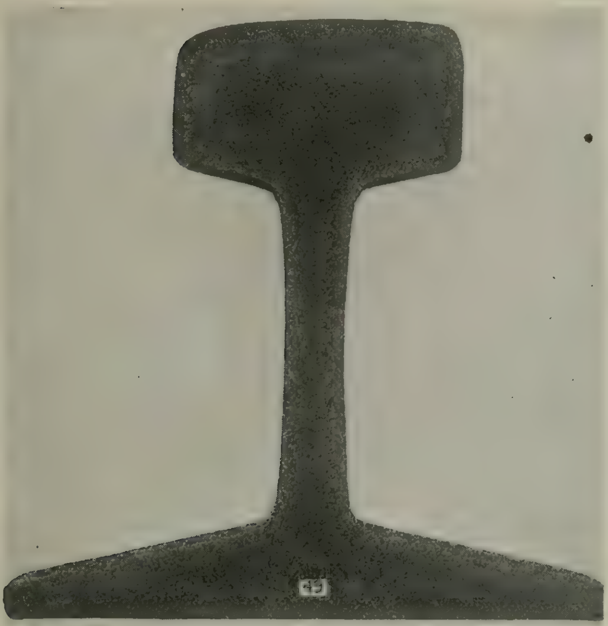

FIG. 138. RAIL 49, ETCHED SECTION.

(50) BROKEN RAIL.

100-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, July, 1906, Heat No. 270; laid in August, 1906, high rail on one-degree 31-min. curve, stone ballast, and removed February 20, 1910. Angular break 19 ft. from leaving end.

C .613; Mn 1.29; P .085; Si .062; T. S. 123,210 lbs. per sq. in.; E. L. 66,620 lbs. per sq. in.; Elong. in 2 in., 16.5%; Red. area 24.70%.

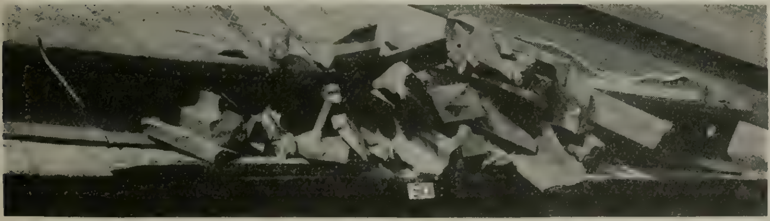

FIG. 139. RAIL 50.

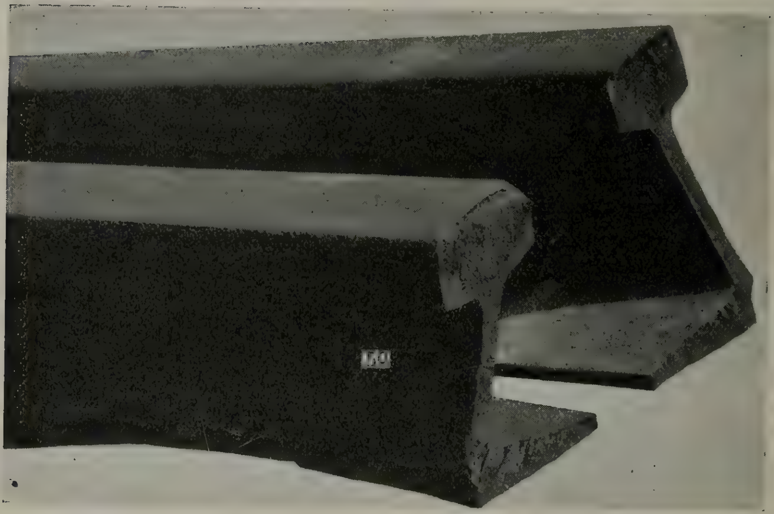

FIG. 140. RAIL 50.

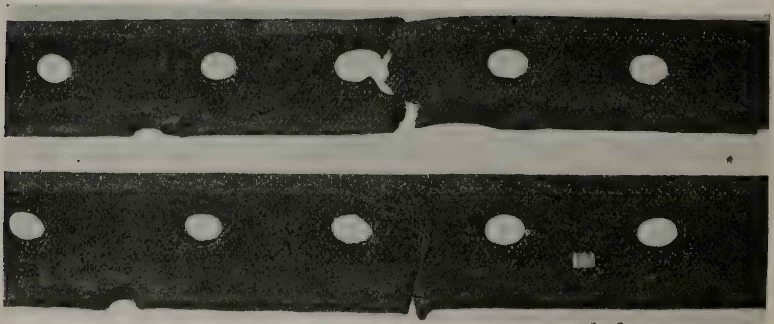

FIG. 141. RAIL 50.

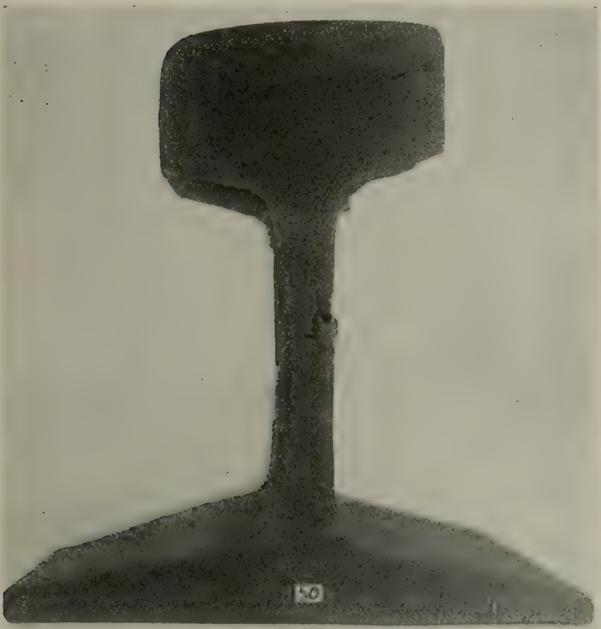

Fig. 142. Rail 50, Etched Section.

(51) BROKEN RAIL.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, March, 1906, Heat No. 2697; laid in June, 1906, low rail on one-degree 10-min. 30-sec. curve, gravel ballast, and removed February 21, 1910. Square break 15 ft. from end.

C .601; Mn 1.04; P .077; Si .128; T. S. 124,800 lbs. per sq. in.; E. L. 81,130 lbs. per sq. in.; Elong. in 2 in., 14%; Red. area 17.23%.

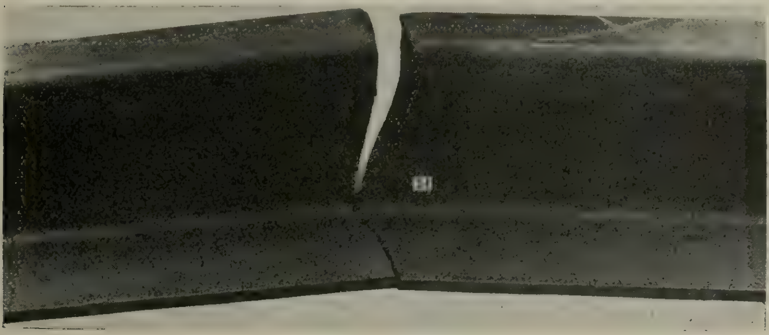

Fig. 143. Rail 51.

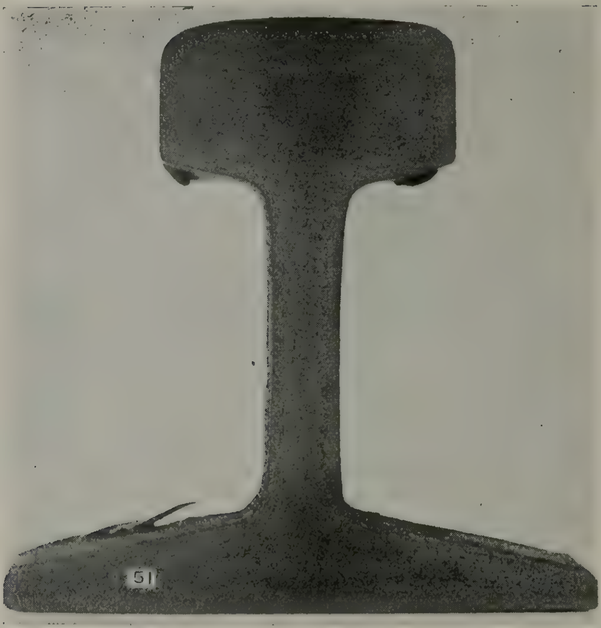

FIG. 144. RAIL 51, ETCHED SECTION.

(52) BROKEN RAIL.

100-lb. P. S. Bessemer, made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 2669; laid April, 1909, high rail on two-degree 20-min. curve, stone ballast, and removed April 16, 1910. Square break 14 in. from receiving end.

C .642; Mn .91; P .097; Si .107; T. S. 116,970 lbs. per sq. in.; E. L. 75,150 lbs. per sq. in.; Elong. in 2 in., 5%; Red. area 4.75%.

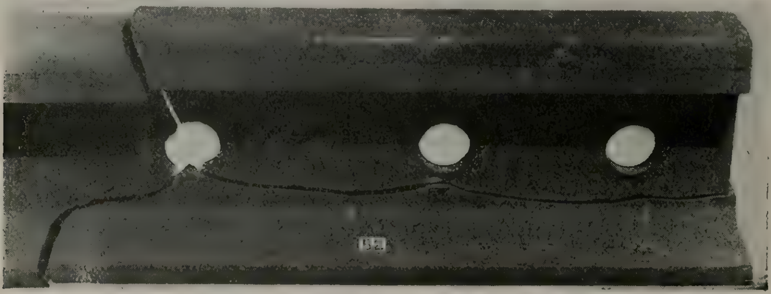

FIG. 145. RAIL 52.

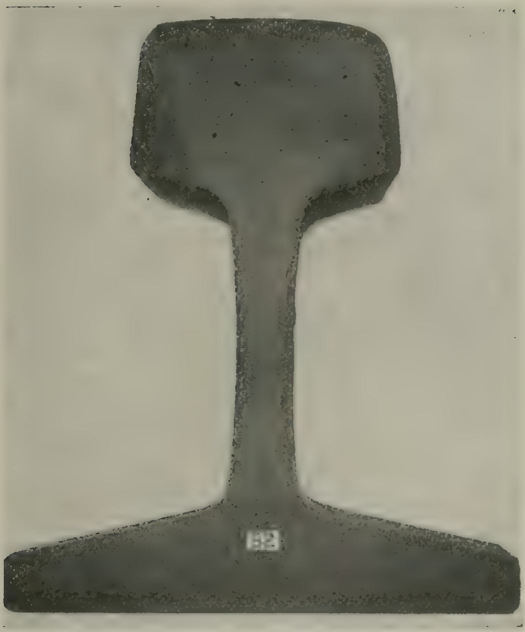

FIG. 146. RAIL 52, ETCHED SECTION.

(53) BROKEN RAIL.

100-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, December, 1909, Heat No. 7948; laid January, 1910, on straight line, limestone ballast, and removed March 11, 1910. Angular break at receiving end 2 ft. 8 in. at the top and 7 in. at the bottom.

C .567; Mn .90; P .111; Si .079; T. S. 118,850 lbs. per sq. in.; E. L. 69,280 lbs. per sq. in.; Elong. in 2 in., 15%; Red. area 21.49%.

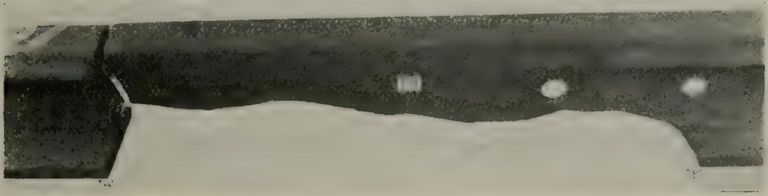

FIG. 147. RAIL 53.

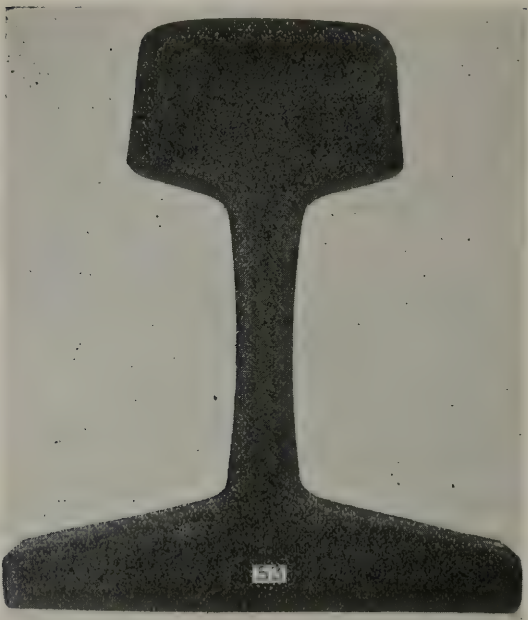

Fig. 148. Rail 53, Etched Section.

(54) BROKEN RAIL.

85-lb. P. S., made by Illinois Steel Company, May, 1909, Heat No. 41441, letter "C;" laid June, 1909, high rail on 59-min. 30-sec. curve, gravel ballast, and removed February 24, 1910. Break six ft. and one-half in. from end.

C .502; Mn .90; P .085; Si .144; T. S. 111,010 lbs. per sq. in.; E. L. 73,460 lbs. per sq. in.; Elong. in 2 in., 21.5%; Red. area 34.03%.

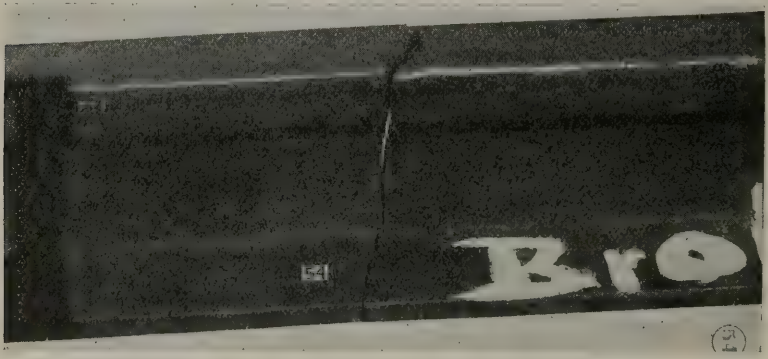

Fig. 149. Rail 54.

FIG. 150. RAIL 54.

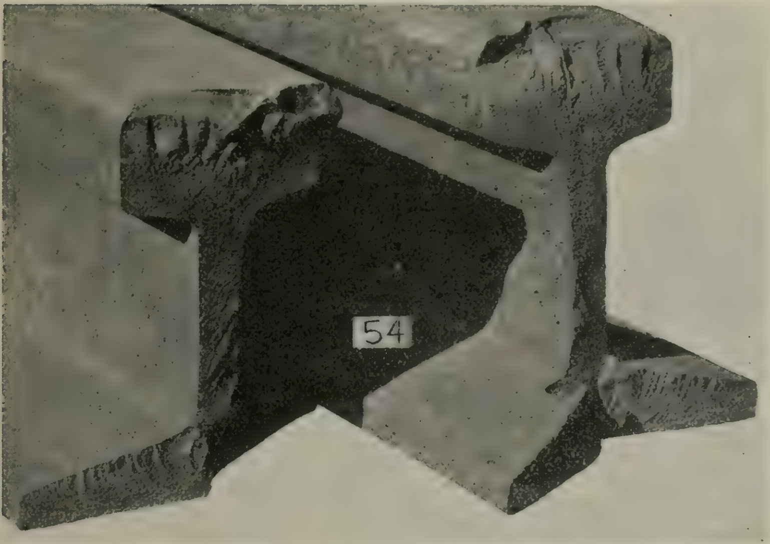

FIG. 151. RAIL 54.

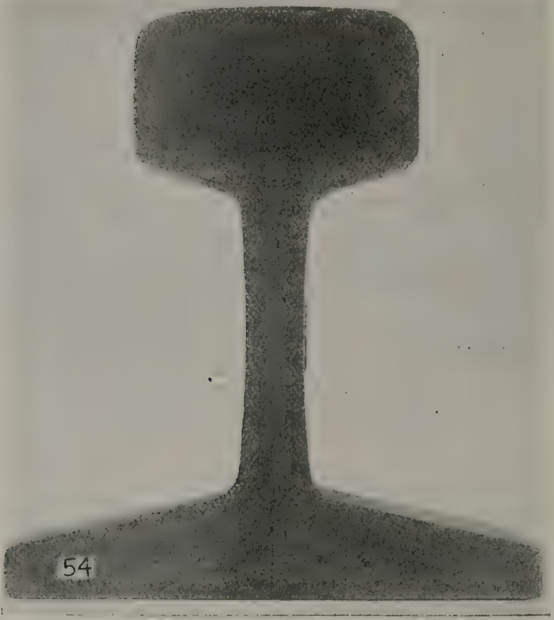

FIG. 152. RAIL 54, ETCHED SECTION.

(55) BROKEN RAIL.

85-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, January, 1910, Heat No. 260, letter "A"; laid March, 1910, low rail on 2-degree curve, limestone ballast, and removed March 17, 1910. Angular break near receiving end, 4 ft. 2 in. at the top and 3 ft. 3 in. at the bottom; web of rail cracked before it was laid, but could not be noticed.

C .584; Mn .95; P .095; Si .154; T. S. 58,550 lbs. per sq. in.; E. L. 58,550 lbs. per sq. in.; Elong. in 2 in., 0.00%; Red. area 0.00%. Flaw in specimen.

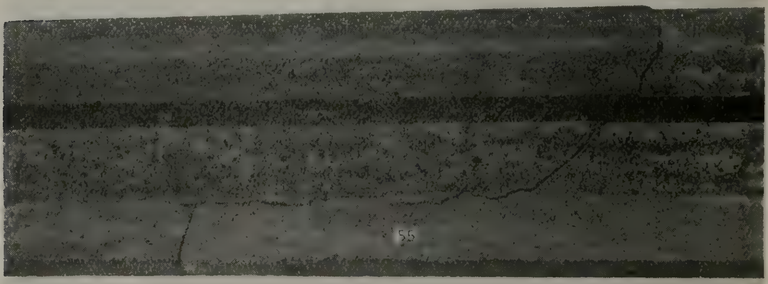

FIG. 153. RAIL 55.

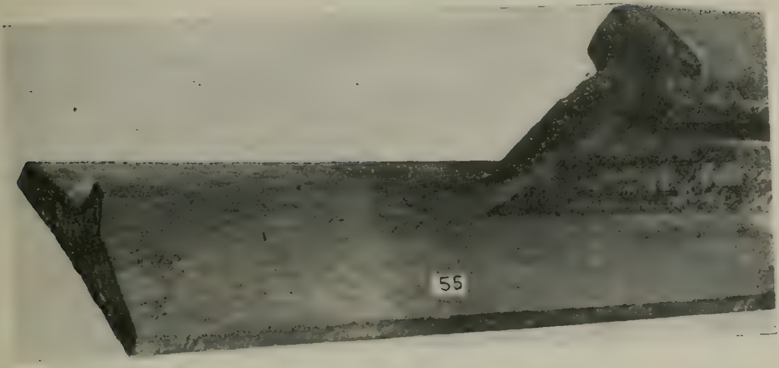

FIG. 154. RAIL 55.

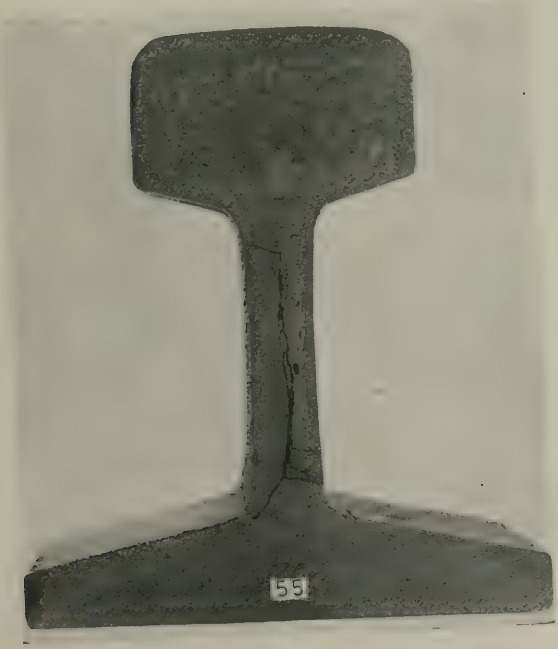

FIG. 155. RAIL 55, ETCHED SECTION.

(56) FLOW OF METAL.

85-lb. P. R. R., made by Carnegie Steel Company, May, 1898, Heat No. 667; laid June, 1898, low rail on 1-degree 2-min. curve, gravel ballast, and removed March 8, 1910. Two ft. of split web, ten ft. from end of rail.

C .412; Mn .69; P .090; Si .102; T. S. 90,120 lbs. per sq. in.; E. L. 60,370 lbs. per sq. in.; Elong. in 2 in., 22.00%; Red. area 38.81%.

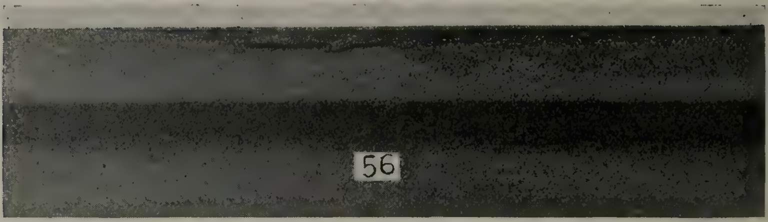

FIG. 156. RAIL 56, VIEW SHOWING SIDE OF HEAD.

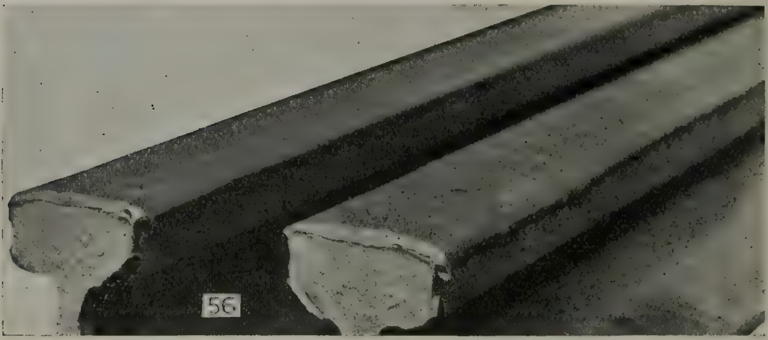

FIG. 157. RAIL 56, SHOWING FLOW OF HEAD.

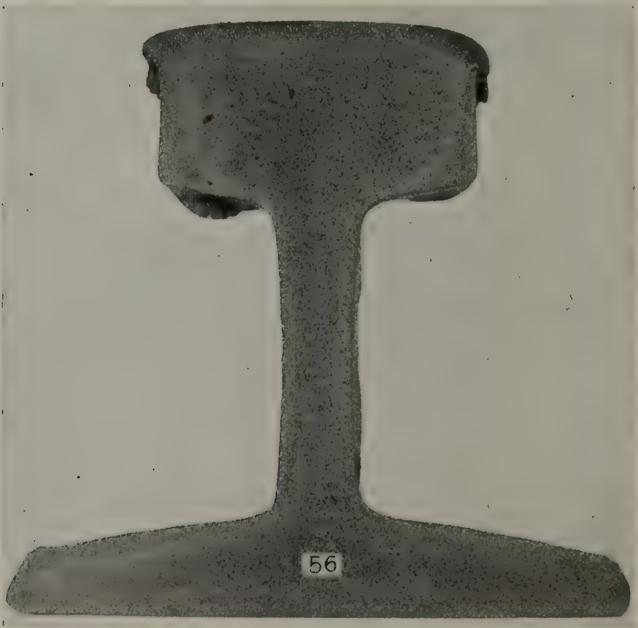

FIG. 158. RAIL 56, ETCHED SECTION.

(57) SPLIT HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, Heat No. 1184; laid June, 1895, on straight line, gravel ballast, and removed April 23, 1910.

C .674; Mn 1.02; P .165; Si .030; T. S. 92,280 lbs. per sq. in.; E. L. 92,280 lbs. per sq. in.; Elong. in 2 in., 1%; Red. area .82%.

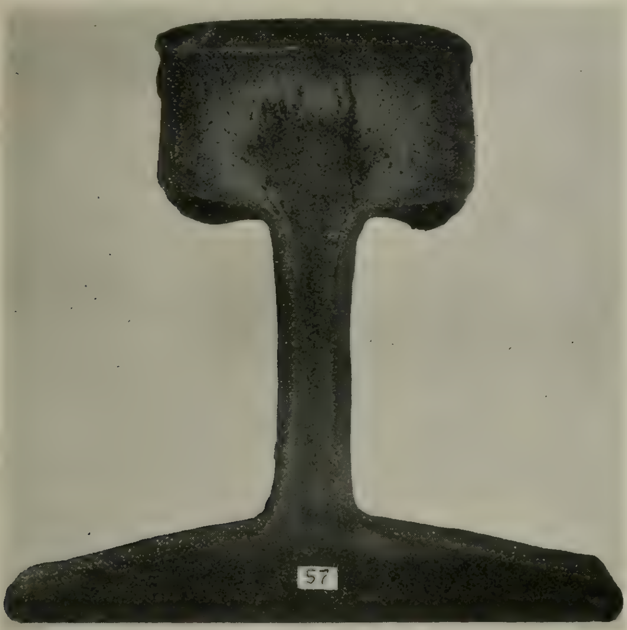

FIG. 159. RAIL 57, ETCHED SECTION.

(58) SPLIT HEAD.

85-lb. P. R. R. standard, made by Carnegie Steel Company, Edgar Thomson Works, December, 1895, Heat No. 6959; laid June, 1896, on straight line, gravel ballast, and removed April 23, 1910. Rail was split in head and cracked under head.

C .632; Mn .92; P .161; S .093; T. S. 118,350 lbs. per sq. in.; E. L. 71,570 lbs. per sq. in.; Elong. in 2 in., 5%; Red. area 5.57%.

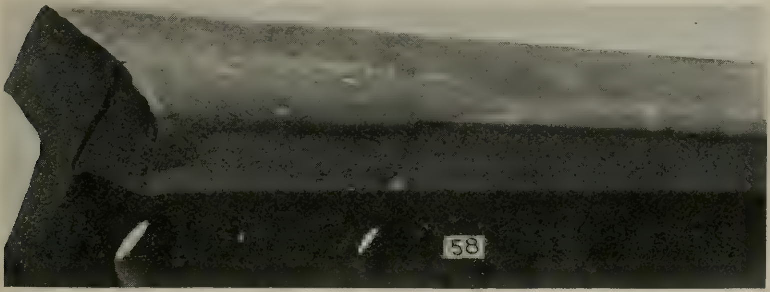

FIG. 160. RAIL 58.

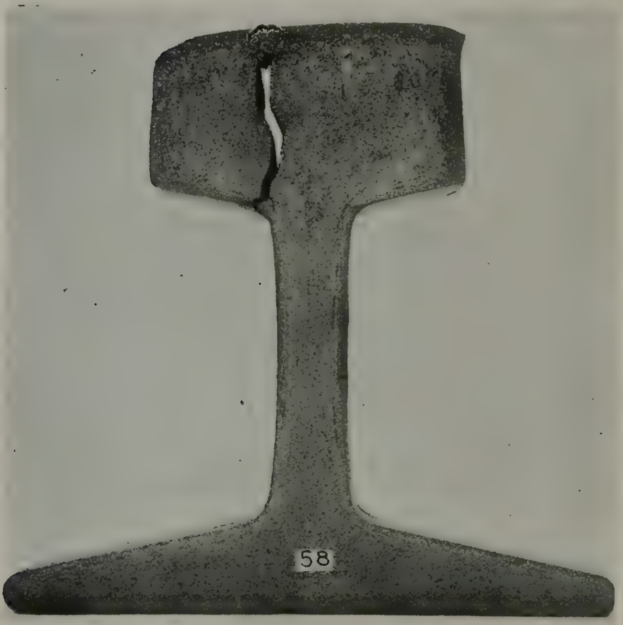

FIG. 161. RAIL 58, ETCHED SECTION.

(59) SPLIT HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, Edgar Thomson Works, December, 1895, Heat No. 692; laid January, 1896, on straight line, gravel ballast, and removed March 16, 1910. Two ft. of split head, one ft. from end of rail, split diagonally across rail.

C .540; Mn .71; P .132; Si .100; T. S. 97,740 lbs. per sq. in.; E. L. 55,900 lbs. per sq. in.; Elong. in 2 in., 8.5%; Red. area 8.62%.

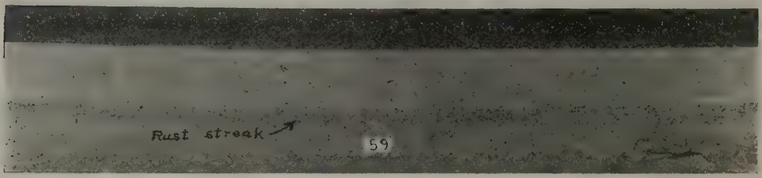

FIG. 162. RAIL 59, SHOWING RUST STREAK UNDER HEAD.

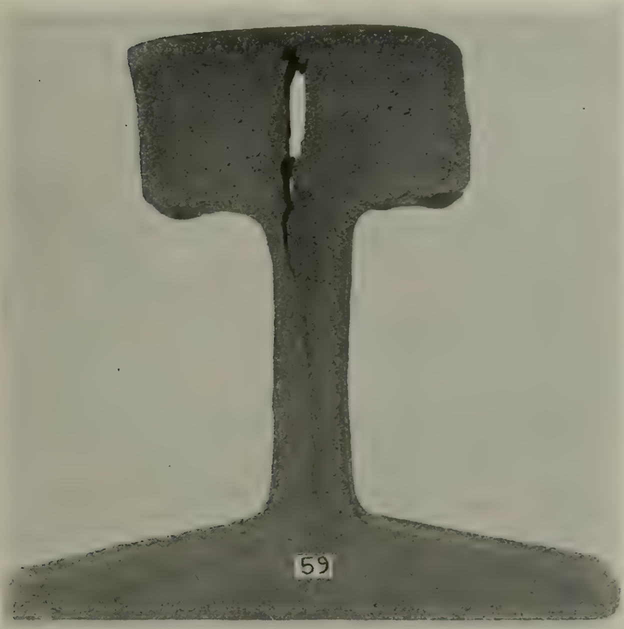

FIG. 163. RAIL 59, ETCHED SECTION.

(60) SPLIT HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, Edgar Thomson Works, December, 1895, Heat No. 6855; laid January, 1896, on straight line, gravel ballast, and removed March 9, 1910. Two ft. of head split diagonally across rail three ft. from end.

C .512; Mn .90; P .097; Si .093; T. S. 107,080 lbs. per sq. in.; E. L. 72,440 lbs. per sq. in.; Elong. in 2 in., 16%; Red. area 22.87%.

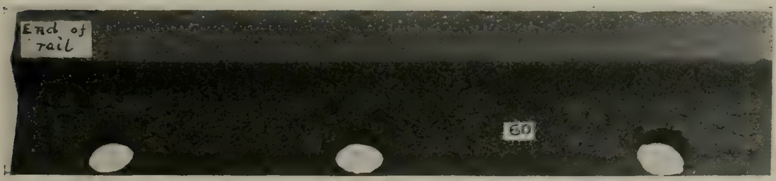

FIG. 164. RAIL 60.

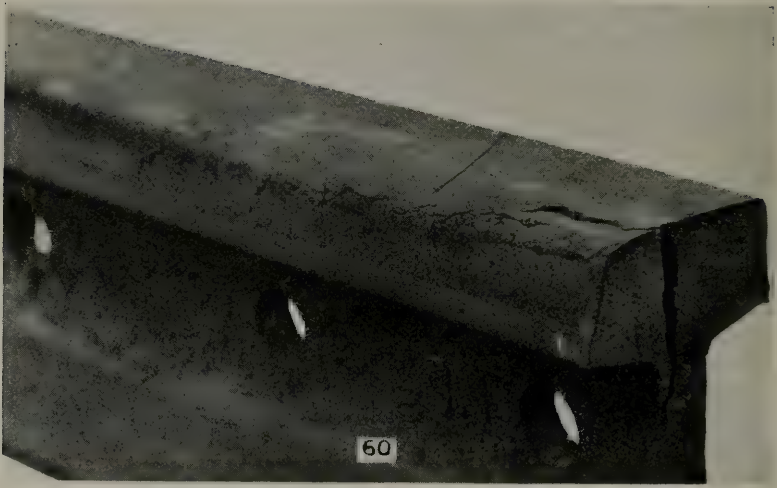

Fig. 165. Rail 60.

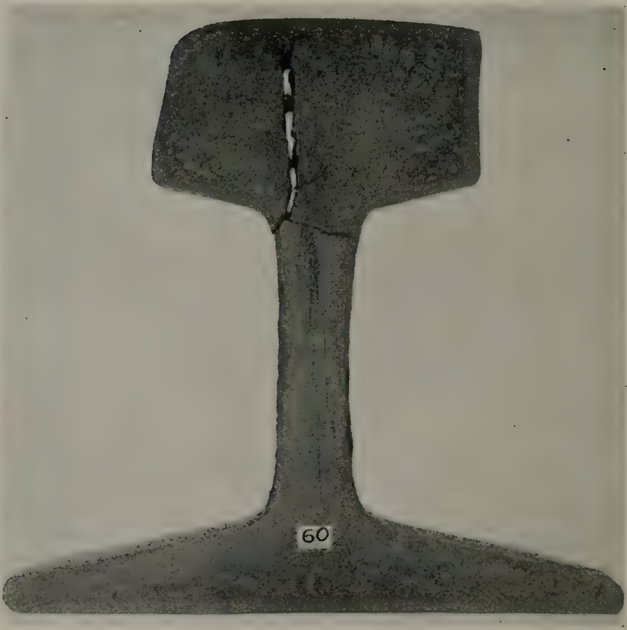

Fig. 166. Rail 60, Etched Section.

(61) SPLIT HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, Edgar Thomson Works, January, 1898; laid February, 1898, on straight line, gravel ballast, and removed January 15, 1910. Four ft. of split head, twelve ft. from end of rail.

C .627; Mn .86; P .175; Si .163; T. S. 113.190 lbs. per sq. in.; E. L. 97,640 lbs. per sq. in.; Elong. in 2 in., 3%; Red. area 3.18%.

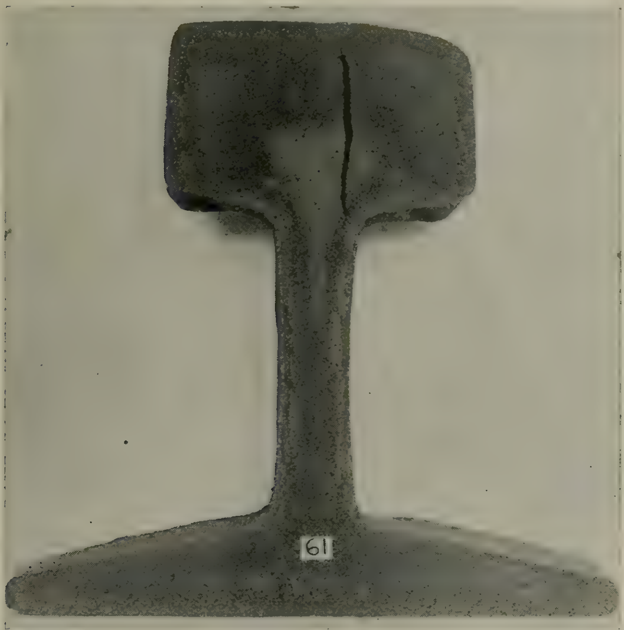

Fig. 167. Rail 61, Etched Section.

(62) SPLIT HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, Edgar Thomson Works, February, 1898, Heat No. 2926; laid February, 1898, on straight line, gravel ballast, and removed March 7, 1910. Six ft. of head split, twelve ft. from end of rail. Split on inside and underneath.

C .567; Mn .86; P .144; Si .093; T. S. 107,150 lbs. per sq. in.; E. L. 67,690 lbs. per sq. in.; Elong. in 2 in., 7%; Red. area 8.01%.

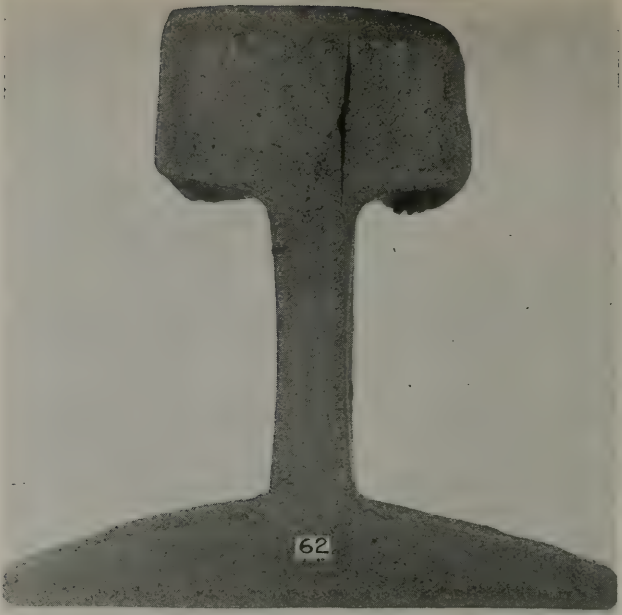

FIG. 168. RAIL 62, ETCHED SECTION.

(63) SPLIT HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, May, 1898, Heat No. 6595; laid May, 1898, on straight line, gravel ballast, and removed April 13, 1910. Two ft. of split head, three ft. six in. from end of rail; split underneath.

C .595; Mn .83; P .120; Si .149; T. S. 116,450 lbs. per sq. in.; E. L. 72,440 lbs. per sq. in.; Elong. in 2 in., 15%; Red. area 20.07%.

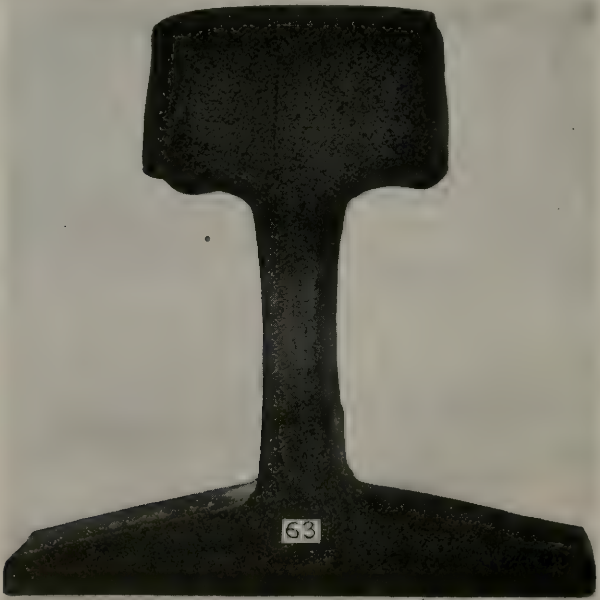

FIG. 169. RAIL 63, ETCHED SECTION.

(64) SPLIT HEAD.

85-lb. P. R. R., made by Carnegie Steel Company, April, 1898, Heat No. 6601; laid May, 1898, on straight line, gravel ballast, and removed March 12, 1910. Two ft. four in. of split head, two ft. eight in. from end of rail; split underneath.

C .531; Mn .71; P .118; Si .102; T. S. 105,470 lbs. per sq. in.; E. L. 65,640 lbs. per sq. in.; Elong. in 2 in., 18%; Red. area 26.12%.

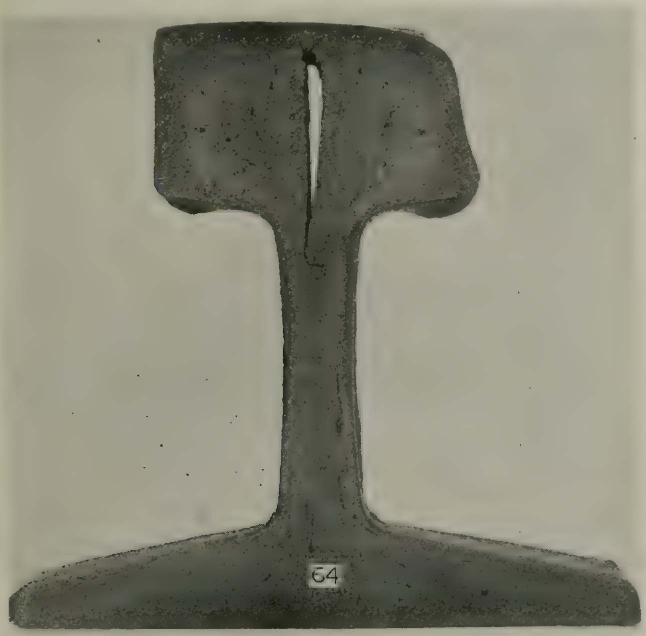

FIG. 170. RAIL 64, ETCHED SECTION.

(65) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1899, Heat No. 6521; laid May, 1899, on straight line, gravel ballast, and removed May 7, 1910. Twelve in. of split head, five ft. from receiving end.

C .612; Mn .97; P .089; Si .146; T. S. 109,410 lbs. per sq. in.; E. L. 82,210 lbs. per sq. in.; Elong. in 2 in., 2.5%; Red. area 2.81%.

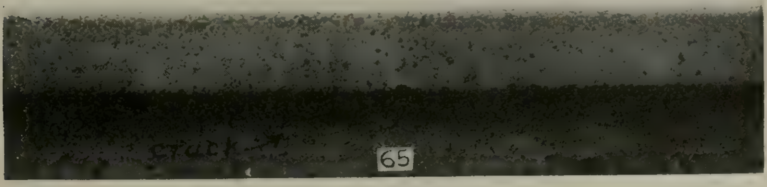

FIG. 171. RAIL 65, SHOWING CRACK UNDER HEAD.

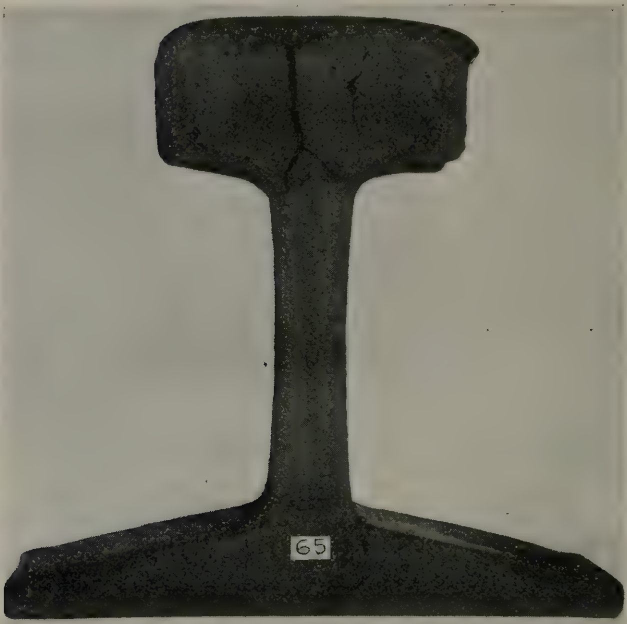

FIG. 172. RAIL 65, ETCHED SECTION.

(66) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1899, Heat No. 1527; laid May, 1899, on straight line, gravel ballast, and removed March 7, 1910. Twelve in. of split head, five ft. from receiving end.

C .605; Mn .95; P .105; Si .121; T. S. 97,910 lbs. per sq. in.; E. L. 73,150 lbs. per sq. in.; Elong. in 2 in., 3%; Red. area 0.00%. Specimen broke at fillet.

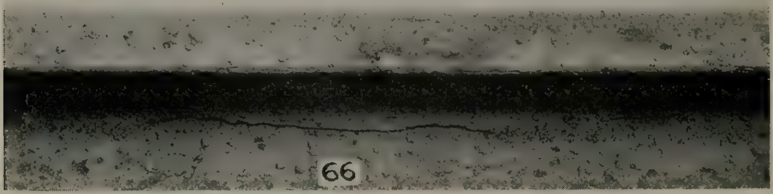

FIG. 173. RAIL 66, SHOWING CRACK UNDER HEAD.

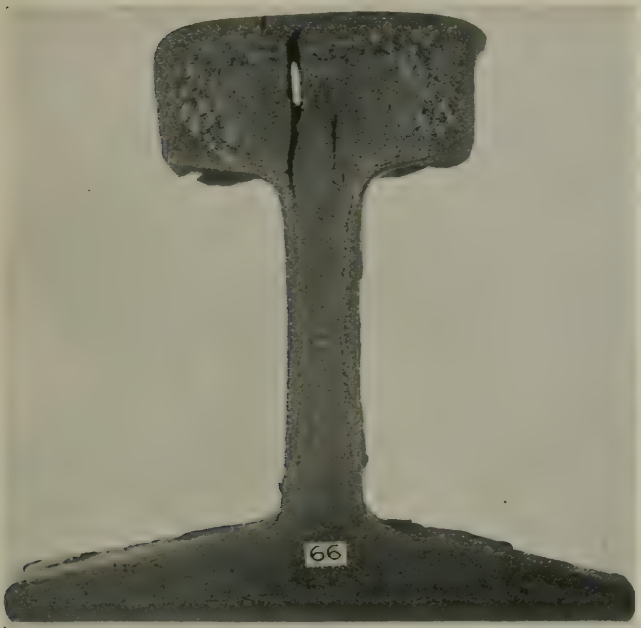

FIG. 174. RAIL 66, ETCHED SECTION.

(67) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1899, Heat No. 5622; laid May, 1899, on straight line, gravel ballast, and removed May 7, 1910. Ten in. of split head, three ft. from receiving end.

C .593; Mn 1.05; P .098; Si .149; T. S. 106,270 lbs. per sq. in.; E. L. 82,420 lbs. per sq. in.; Elong. in 2 in., 3.5%; Red. area 4.33%.

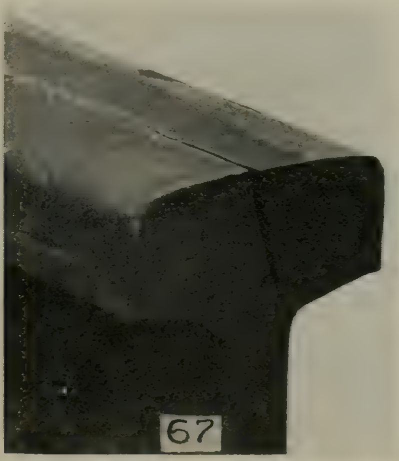

FIG. 175. RAIL 67.

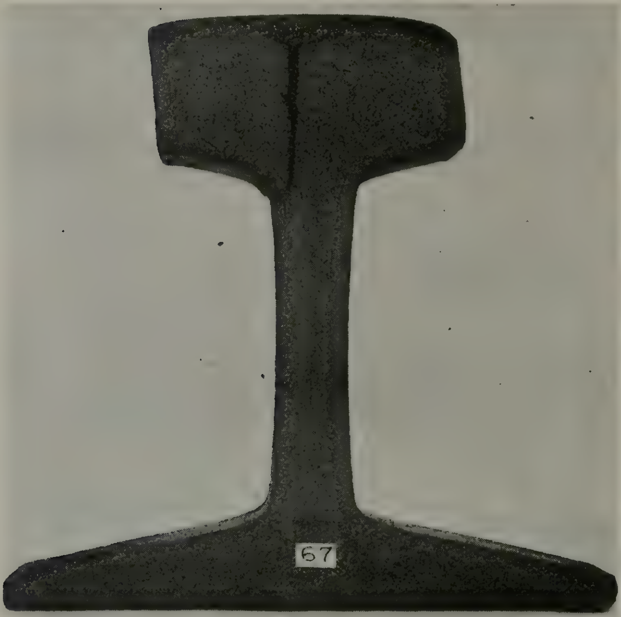

FIG. 176. RAIL 67, ETCHED SECTION.

(68) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1899, Heat No. 8589; laid April, 1905, on straight line, gravel ballast, and removed March 31, 1910. Split head accompanied by seam in rail, defect starting fifteen ft. from end of rail and extending for two ft. Rail watched for ten months.

C .613; Mn .90; P .111; Si .128; T. S. 74,330 lbs. per sq. in.; E. L. 74,330 lbs. per sq. in.; Elong. in 2 in., 1%; Red. area .76%.

FIG. 177. RAIL 68.

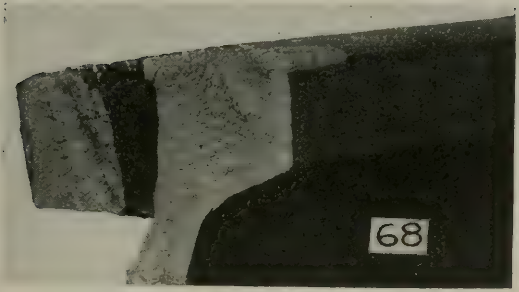

FIG. 178, RAIL 68.

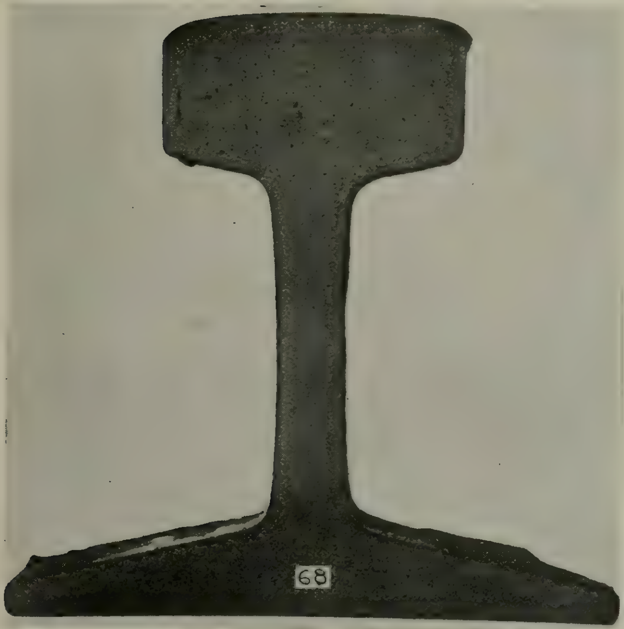

FIG. 179. RAIL 68, ETCHED SECTION.

(69) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, March, 1899, Heat No. 10901; laid May, 1899, on straight line, gravel ballast, and removed April 27, 1910. Crack on top of ball three ft. long and crack underneath ball eleven ft. long and about nine ft. from leaving end.

C .623; Mn .88; P .106; Si .111; T. S. 122,140 lbs. per sq. in.; E. L. 77,860 lbs. per sq. in.; Elong. in 2 in., 5.5%; Red. area 0.00%. Broke in thread.

FIG. 180. RAIL 69, CRACK UNDER HEAD.

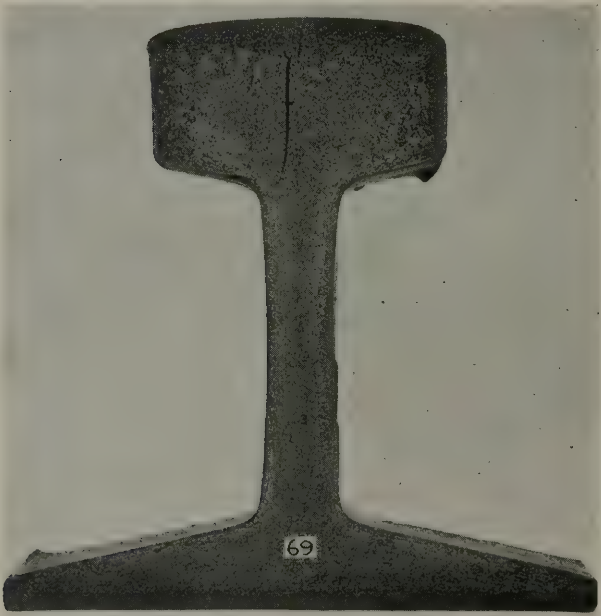

FIG. 181. RAIL 69, ETCHED SECTION.

(70) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, October, 1900, Heat No. 24321, Bessemer steel; laid October, 1909, low rail on 2-degree curve, gravel ballast, and removed March 21, 1910 Split head accompanied by seam, defect starting fifteen ft. from end and extending four ft.

C .545; Mn .91; P .124; Si .102; T. S. 115,130 lbs. per sq. in.; E. L. 77,710 lbs. per sq. in.; Elong. in 2 in., 15%; Red area 18.30%.

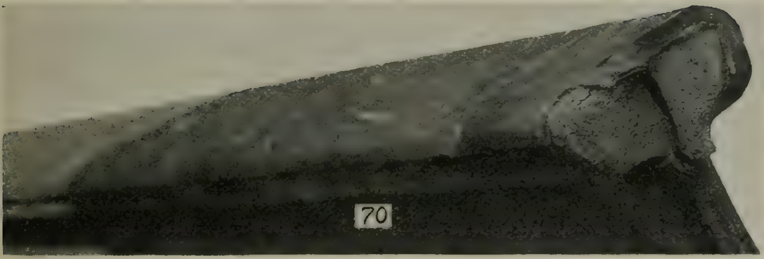

FIG. 182. RAIL 70.

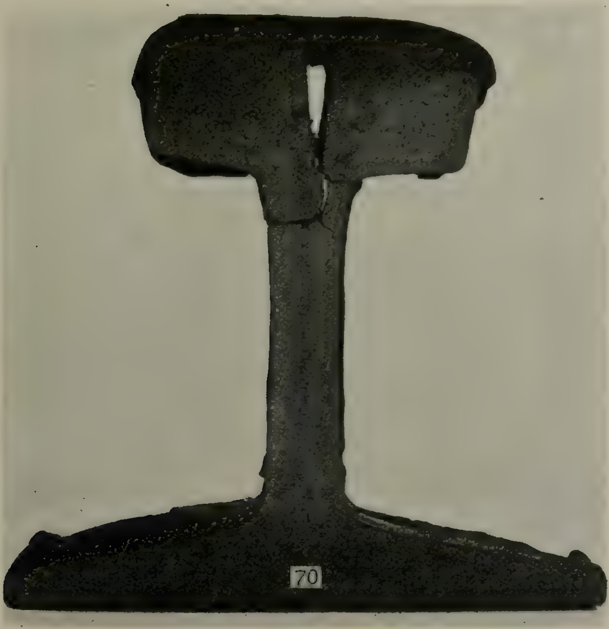

FIG. 183. RAIL 70. ETCHED SECTION.

(71) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, May, 1902; laid July, 1902, on straight line, gravel ballast, and removed March 8, 1910. Seven ft. of split head at receiving end.

C .505; Mn .63; P .096; Si .042; T. S. 88,660 lbs. per sq. in.; E. L. 55,490 lbs. per sq. in.; Elong. in 2 in., 10%; Red. area 12.83%.

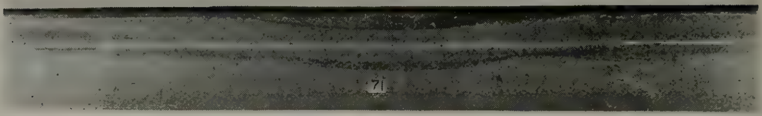

FIG. 184. RAIL 71, SHOWING SAG OF HEAD AND CRACK UNDER HEAD.

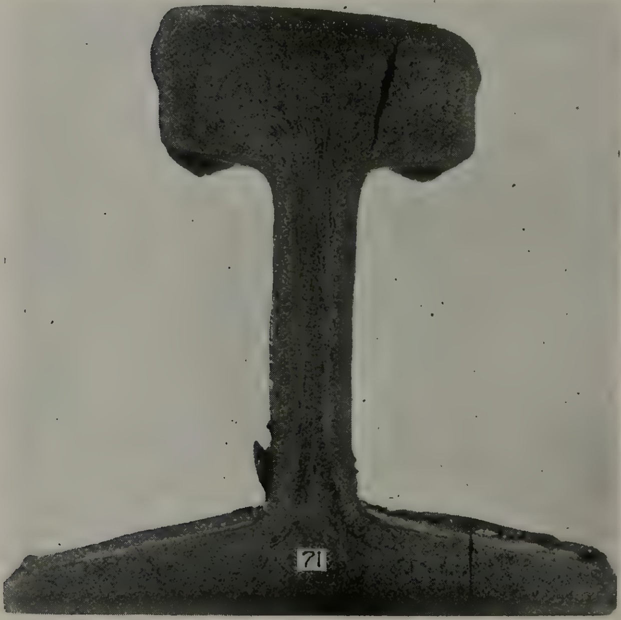

FIG. 185. RAIL 71, ETCHED SECTION.

(72) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, January, 1903, Heat No. 270; laid 1903, on straight line, gravel ballast, and removed March 12, 1910. This rail was split through head, along side of stem about sixteen in. long and about twenty-four in. from receiving end, on inside of rail. No seams or hollow-head.

C .709; Mn .80; P .194; Si .037; T. S. 131,980 lbs. per sq. in.; E. L. 88,140 lbs. per sq. in.; Elong. in 2 in., 5.5%; Red. area 4.36%.

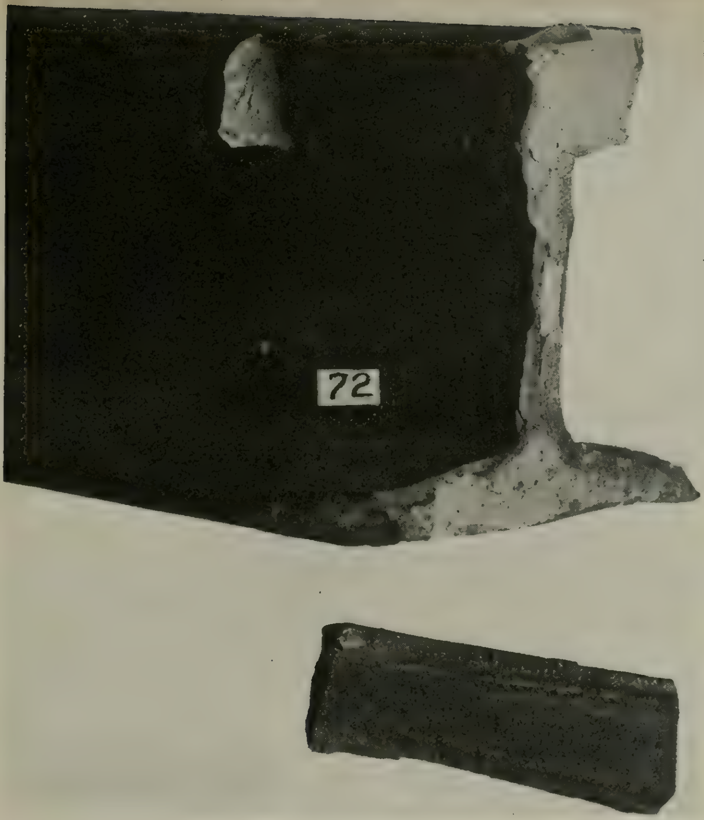

FIG. 186. RAIL 72.

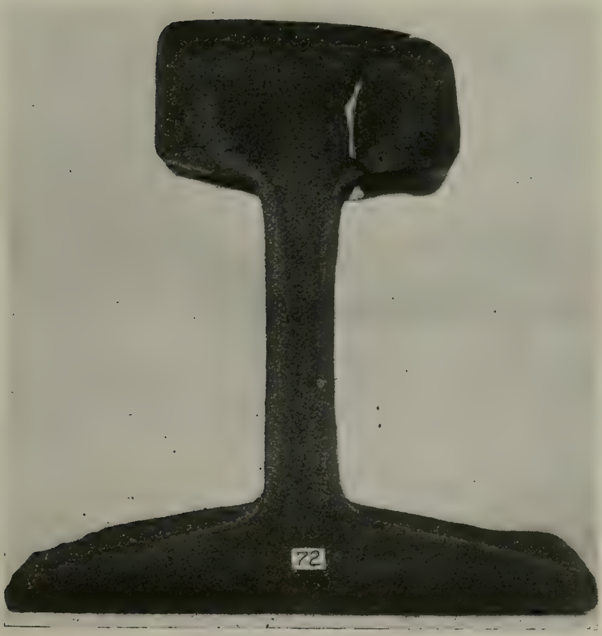

FIG. 187. RAIL 72, ETCHED SECTION.

(73) SPLIT HEAD.

85-lb. A. S. C. E., made by Carnegie Steel Company, Edgar Thomson Works, January, 1903, Heat No. 140; laid April, 1903, on straight line, gravel ballast, and removed April 18, 1910. There is a crack which started about five ft. from receiving end on inside and is about seven ft. long, and on the outside it is about fifteen ft. long. Split is in web just under ball of rail.

C .530; Mn .61; P .150; Si .064; T. S. 85,690 lbs. per sq. in.; E. L. 52,980 lbs. per sq. in.; Elong. in 2 in., 4%; Red. area 5.5%.

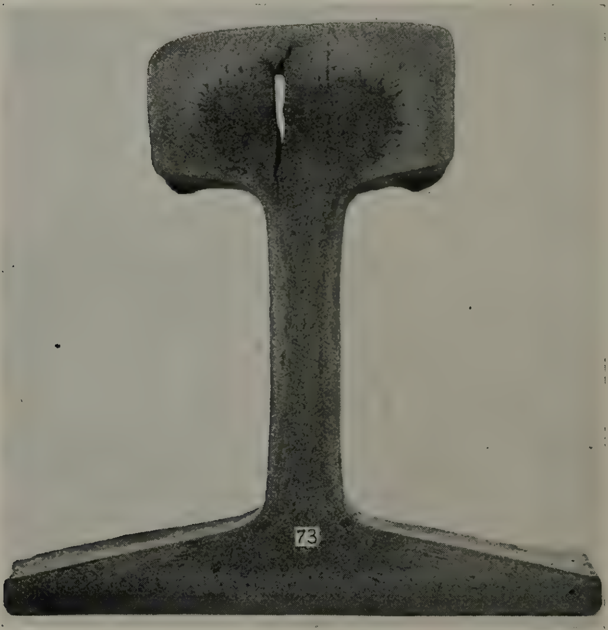

FIG. 188. RAIL 73, ETCHED SECTION.

(74) SPLIT HEAD.

80-lb. A. S. C. E., made by Tennessee Coal & Iron Company, September, 1903, Open-Hearth, Heat No. 10722; laid September, 1903, high rail on 2-degree curve, gravel ballast, and removed December 11, 1909. Top of rail battered twelve ft. from end.

C .620; Mn 1.08; P .095; S .020; T. S. 129,880 lbs. per sq. in.; E. L. 89,270 lbs. per sq. in.; Elong. in 2 in., 12.5%; Red. area 16.6%.

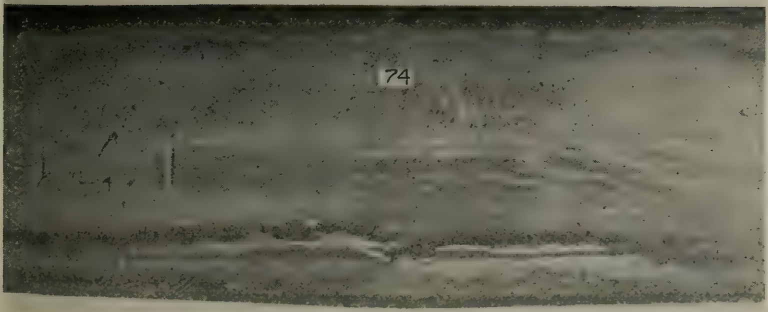

FIG. 189. RAIL 74, TOP VIEW SHOWING SCALY HEAD.

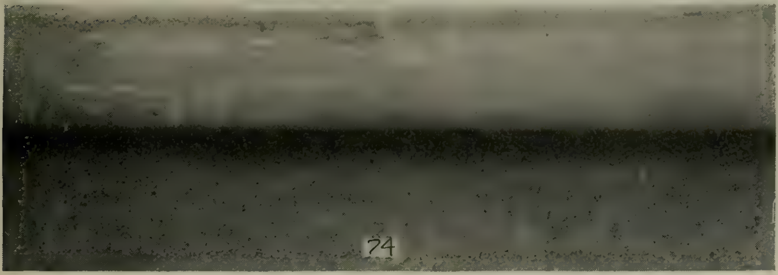

FIG. 190. RAIL 74, SIDE VIEW SHOWING SCALES ON TOP OF HEAD.

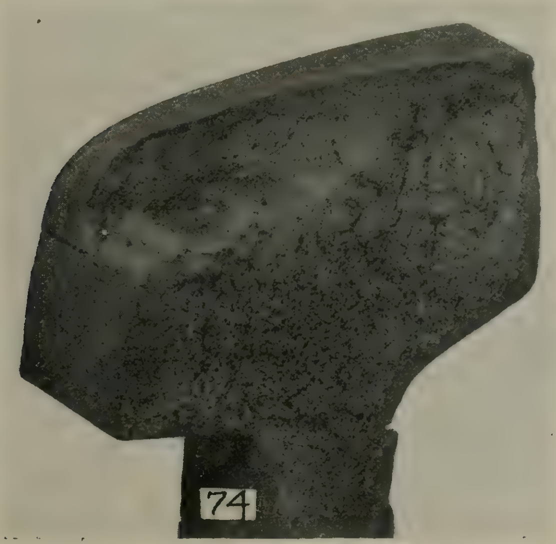

FIG. 191. RAIL 74.

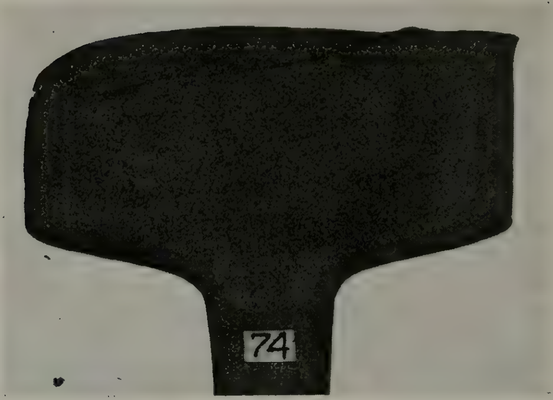

FIG. 192. RAIL 74, ETCHED CROSS-SECTION ½ IN. FROM BREAK.

(75) SPLIT HEAD.

85-lb. A. S. C. E., made by Lorain Steel Company, December, 1905, Heat No. 7531; laid March, 1906, on straight line, rock ballast, and removed December 18, 1909. Flaw along the web, commencing two ft. from end and extending four and a half ft. just under the ball of rail.

C .670; Mn .655; P .142; S .124; Si .057; T. S. 129,081 lbs. per sq. in.; E. L. 80,969 lbs. per sq. in.; Elong. in 2 in., 6.25%; Red. area 7.09%.

FIG. 193. RAIL 75, CRACK UNDER HEAD—OUTSIDE.

FIG. 194. RAIL 75, CRACK UNDER HEAD—INSIDE.

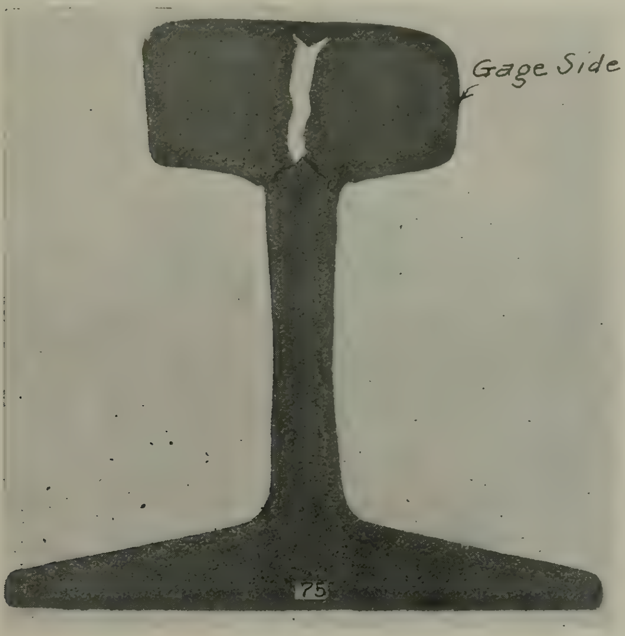

FIG. 195. RAIL 75, ETCHED SECTION.

(76) SPLIT HEAD.

100-lb. A. S. C. E. 10001, made by Illinois Steel Company, May, 1907, Heat No. 544804; laid September, 1907, on straight line, and removed September 21, 1909. About three ft. from end rail flattened out for about six ft. long and separated from neck of rail.

C .588; P .122; Mn .958; S .082; Si .099; T. S. 115,480 lbs. per sq. in.; E. L. 62,360 lbs. per sq. in.; Elong. in 2 in., 12.5%; Red. area 22.5%.

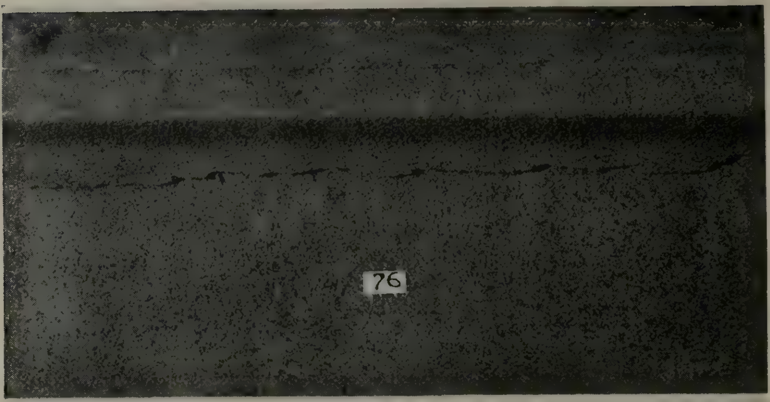

FIG. 196. RAIL 76, CRACK UNDER HEAD.

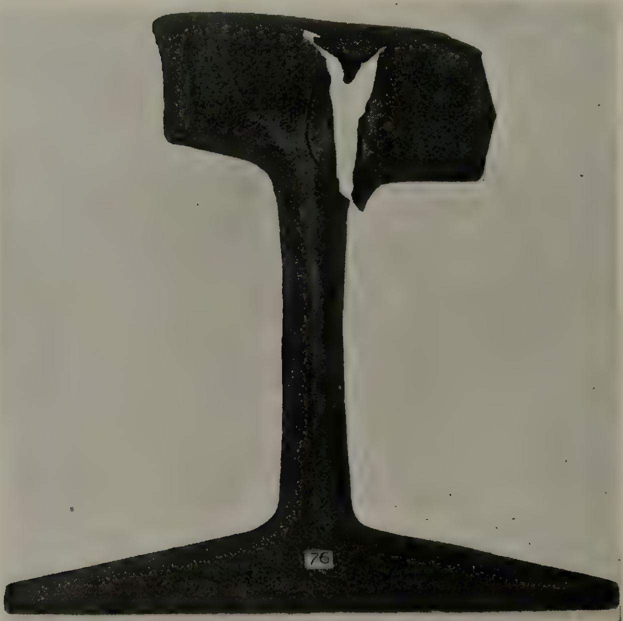

FIG. 197. RAIL 76, ETCHED SECTION.

(77) SPLIT HEAD.

100-lb. P. S., made by Cambria Steel Company, December, 1907, Heat No. 27759, letter "A"; laid August, 1908, on straight line, limestone ballast, and removed March 17, 1910. Split head, beginning 15 in. from end and extending two ft.

C .607; Mn .97; P .116; Si .095; T. S. 118,120 lbs. per sq. in.; E. L. 82,140 lbs. per sq. in.; Elong. in 2 in., 7%; Red. area 7.49%.

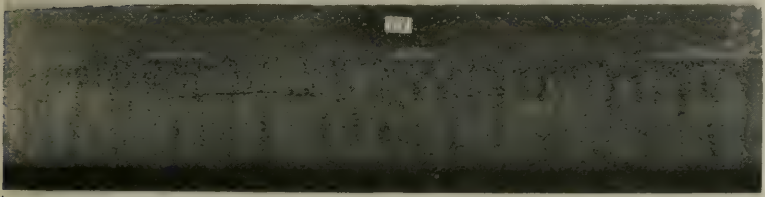

Fig. 198. Rail 77, Crack on Head.

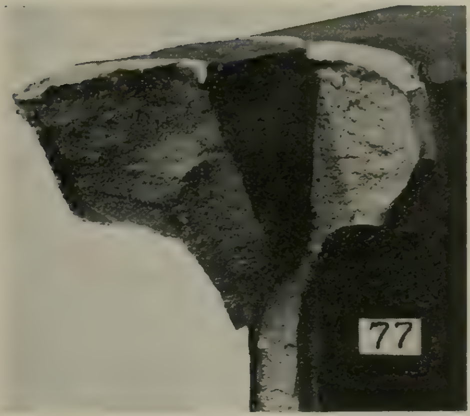

Fig. 199. Rail 77.

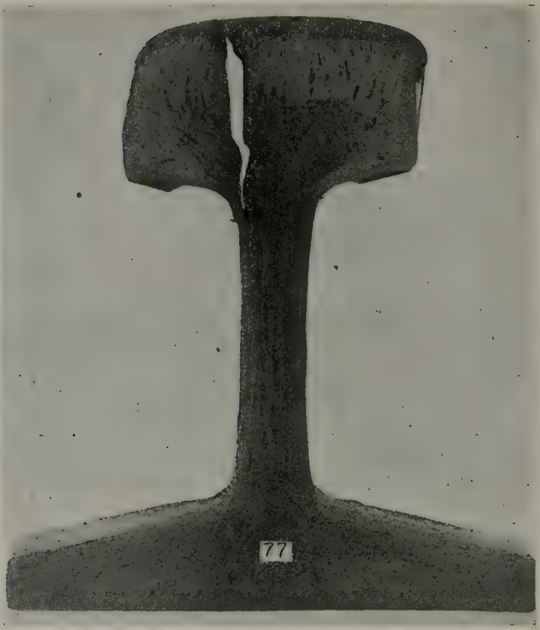

FIG. 200. RAIL 77, ETCHED SECTION.

(78) SPLIT HEAD.

100-lb. P. S., made by Cambria Steel Company, November, 1907; laid August, 1908, low rail on 6-degree 5-min. curve, limestone ballast, and removed November 20, 1909. Split head four ft. from receiving end, defect one ft. and ten in. long.

C .603; Mn 1.06; P .120; Si .098; T. S. 118,610 lbs. per sq. in.; E. L. 77,970 lbs. per sq. in.; Elong. in 2 in., 16.5%; Red. area 29.86%.

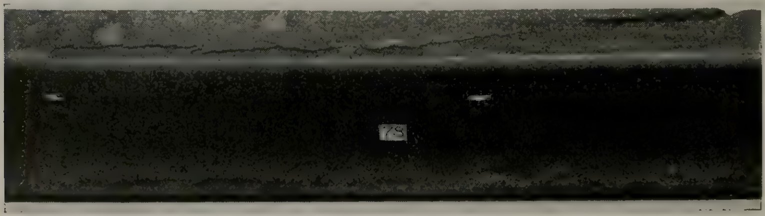

FIG. 201. RAIL 78.

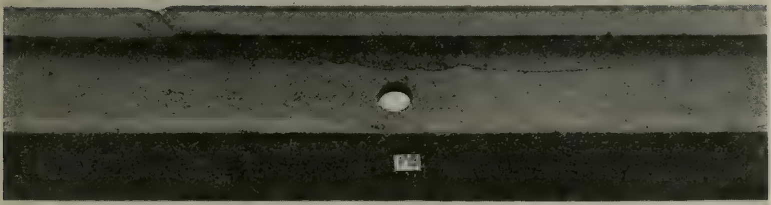

FIG. 202. RAIL 78.

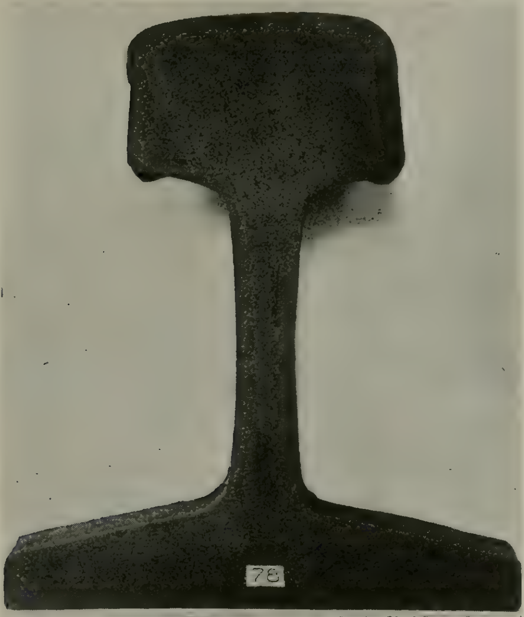

FIG. 203. RAIL 78, ETCHED SECTION.

(79) SPLIT HEAD.

85-lb. P. S. O. H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 55069, Letter "G"; laid June, 1909, straight line, gravel ballast, and removed February 23, 1910.

C .682; Mn .69; P .047; Si .130; T. S. 113,200 lbs. per sq. in.; E. L. 78,260 lbs. per sq. in.; Elong. in 2 in., 13.5%; Red. area 16.92%.

Comments by R. W. Hunt & Company:

An examination of the etching indicates that the cause of the failure was the inclusion of soft steel, as a result of scrap material used on the ingot stools, as described in previous reports. Drillings were taken from the included material "A" in the photograph, and our analysis showed results as follows:

Carbon by combustion	.118%
Phosphorus	.102%

Aside from this included material the chemical and physical character of the steel is excellent.

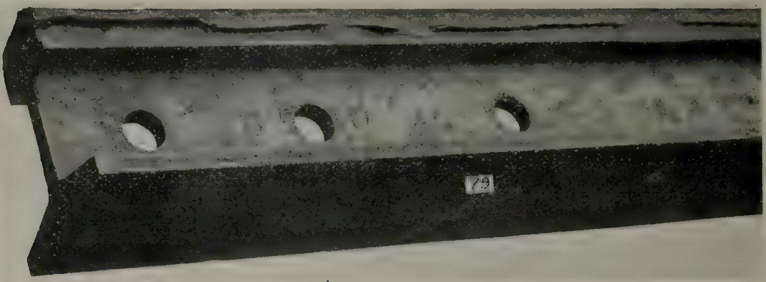

FIG. 204. RAIL 79.

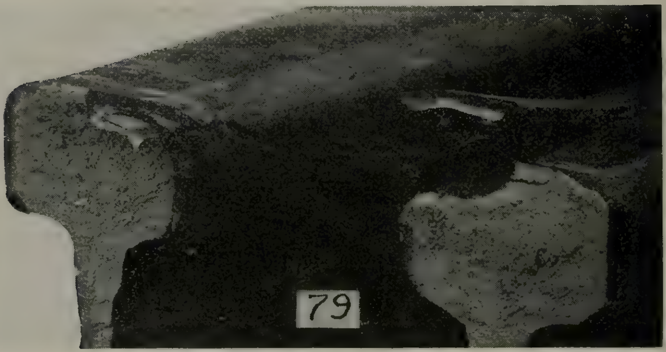

FIG. 205. RAIL 79, CUT 18 IN. FROM RECEIVING END.

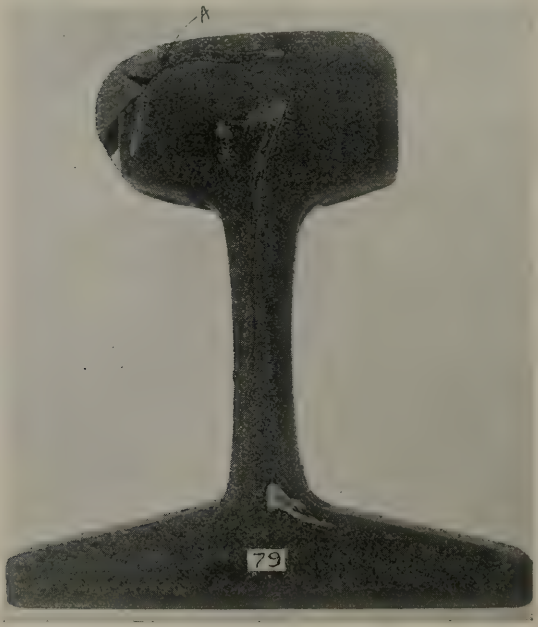

FIG. 206. RAIL 79, ETCHING SHOWING STEEL INCLUSIONS.

(80) SPLIT HEAD.

85-lb. P. S. O. H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 8530; laid May, 1909, low rail on 3-degree 42-min. 30-sec. curve, gravel ballast, and removed February 1, 1910. Two in. of head split, 10 ft. 6 in., 15 ft. 8 in., 16 ft. 10 in. from end of rail.

C .737; Mn .75; P .031; Si .111; T. S. 117,170 lbs. per sq. in.; E. L 88,280 lbs. per sq. in.; Elong. in 2 in., 15%; Red. area 22.52%.

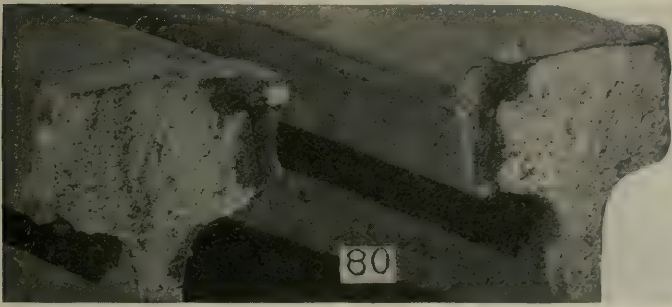

Fig. 207. Rail 80.

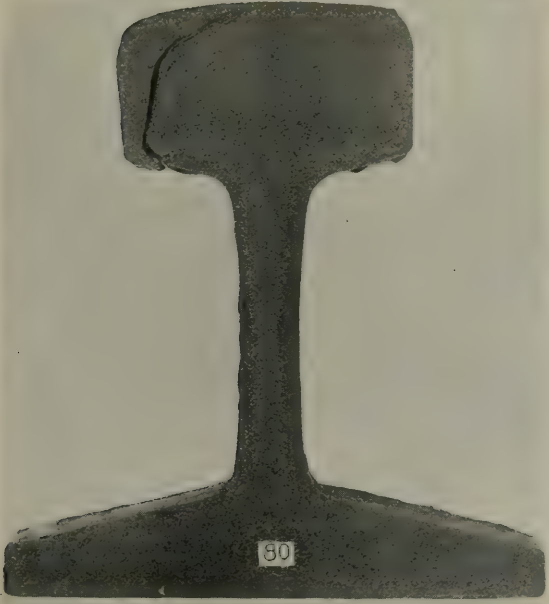

Fig. 208. Rail 80, Etching Showing Steel Inclusion.

(81) SPLIT HEAD.

85-lb. P. S. O. H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 8530; laid May, 1909, low rail on 3-degree 43-min. 30-sec. curve, gravel ballast, and removed February 14, 1910. Twelve ft. of split head, eight ft. from end. Metal on top of ball scaled off before defect was noticed.

C .754; Mn .69; P .039; Si .135; T. S. 129,550 lbs. per sq. in.; E. L. 78,170 lbs. per sq. in.; Elong. in 2 in., 14%; Red. area 10.17%.

FIG. 209. RAIL 81, CRACK ON TOP OF HEAD.

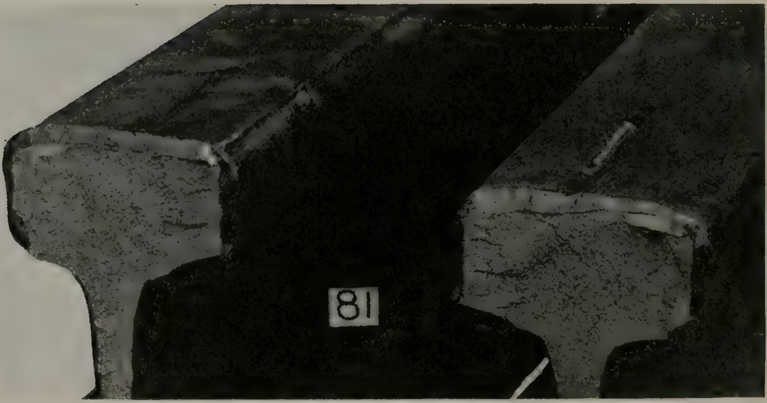

FIG. 210. RAIL 81, CUT 14 FT. 6 IN. FROM END.

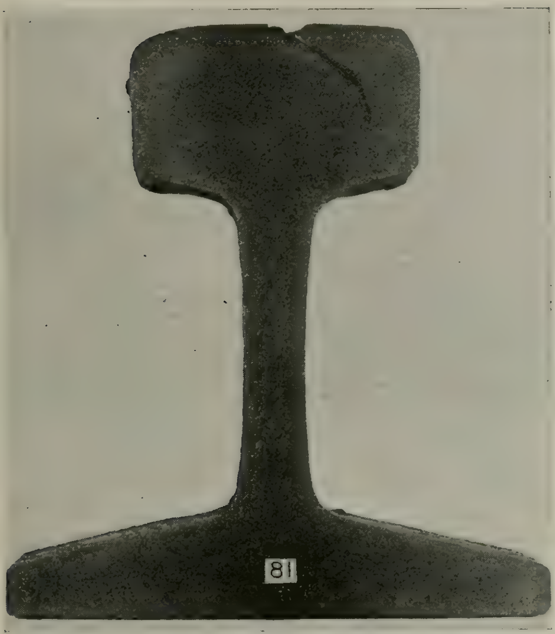

FIG. 211. RAIL 81, ETCHING SHOWING STEEL INCLUSION.

(82) SPLIT HEAD.

85-lb. P. S. O. H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 8530; laid May, 1909, high rail on 3-degree 43-min. 30-sec. curve, gravel ballast, and removed February 14, 1910. Twenty-two ft. of split head, eight in. from end. Metal on top of ball scaled off before defect was noticed.

C .685; Mn .74; P .034; Si .167; T. S. 114,770 lbs. per sq. in.; E. L. 69,590 lbs. per sq. in.; Elong. in 2 in., 16%; Red. area 22.87%.

Comments by R. W. Hunt & Company:

It is apparent from a consideration of the etching that the cause of the failure was the inclusion of soft steel. Aside from this the character of the steel is quite satisfactory.

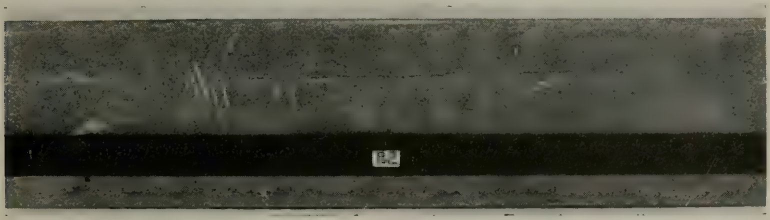

FIG. 212. RAIL 82, CRACK ON TOP OF HEAD.

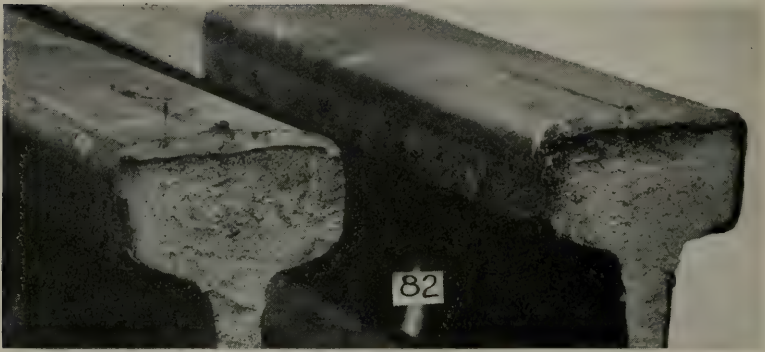

Fig. 213. Rail 82, Cut 8 ft. 6 in. from End.

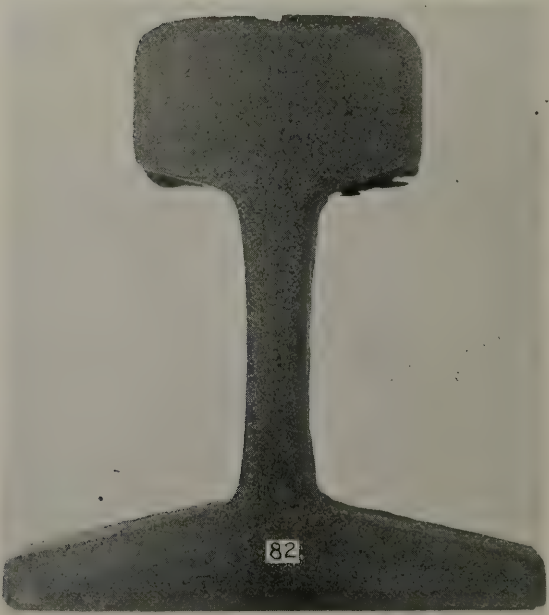

Fig. 214. Rail 82, Etched Section.

(83) SPLIT HEAD.

85-lb. P. S. O. H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 6043, Letter "B"; laid May, 1909, on straight line, gravel ballast, and removed March 4, 1910. Small defects run entire length of rail from one to two ft. apart.

C .754; Mn .75; P .031; Si .110; T. S. 120,800 lbs. per sq. in.; E. L. 80,010 lbs. per sq. in.; Elong. in 2 in., 13.5%; Red. area 18.7%.

Comment by R. W. Hunt & Company:

The etching indicates that the cause of the failure of this rail was the inclusion of soft steel in the casting of the rail ingots at the time of manufacture, as has been described in a previous report.

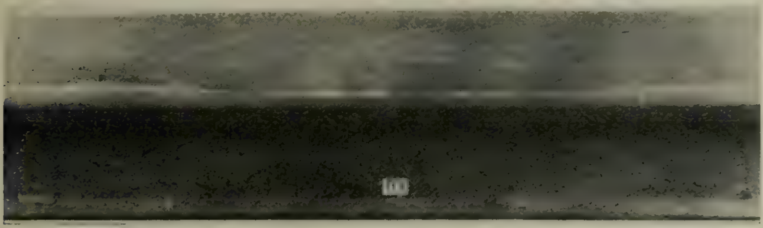

FIG. 215. RAIL 83, SHOWING SPREAD OF HEAD.

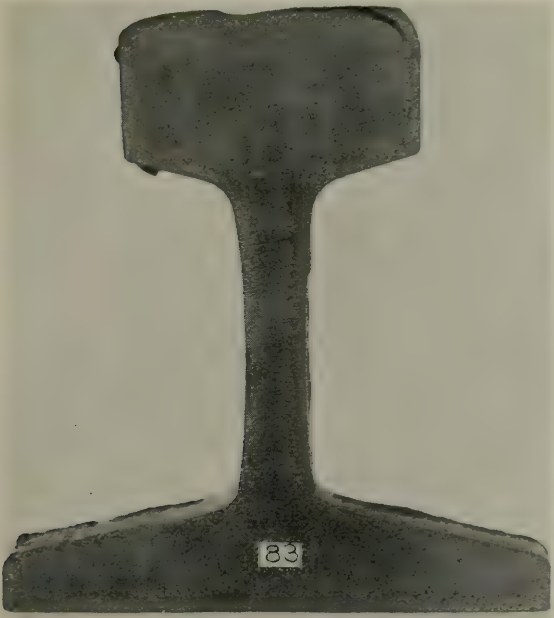

FIG. 216. RAIL 83, ETCHED SECTION.

(84) SPLIT HEAD.

85-lb. P. S. O. H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 50069, Letter "G"; laid June, 1909, on gravel ballast, and removed February 15, 1910. Split head accompanied by seam, defect seven and one-half ft. long.

C .813; Mn .70; P .022; Si .082; T. S. 120,380 lbs. per sq. in.; E. L. 82,270 lbs. per sq. in.; Elong. in 2 in., 13%; Red. area 8.23%.

Comment by R. W. Hunt & Company:

It is apparent from a consideration of the etching that the inclusion of soft steel was the cause of the failure. Aside from this the steel showed quite a satisfactory character.

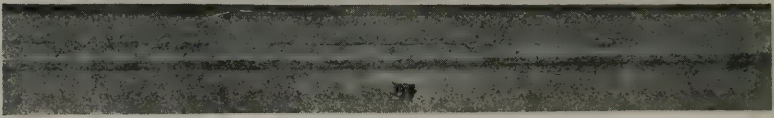

FIG. 217. RAIL 84, SHOWING CRACK ON HEAD.

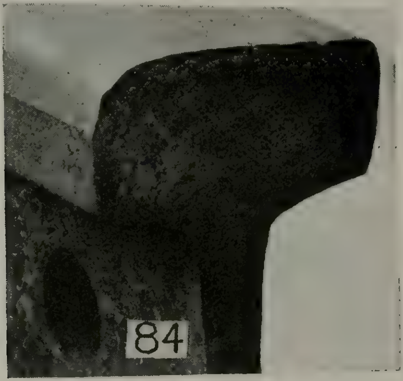

FIG. 218. RAIL 84, END OF RAIL SHOWING SPLIT.

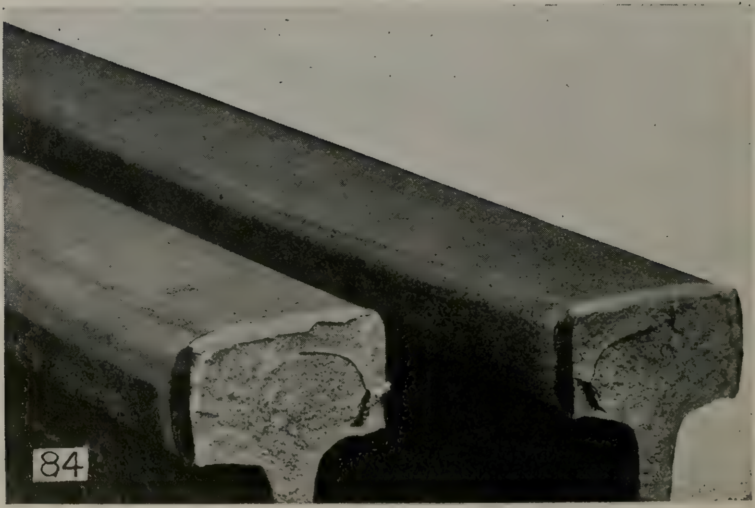

FIG. 219. RAIL 84, CUT 6 FT. 2 IN. FROM END.

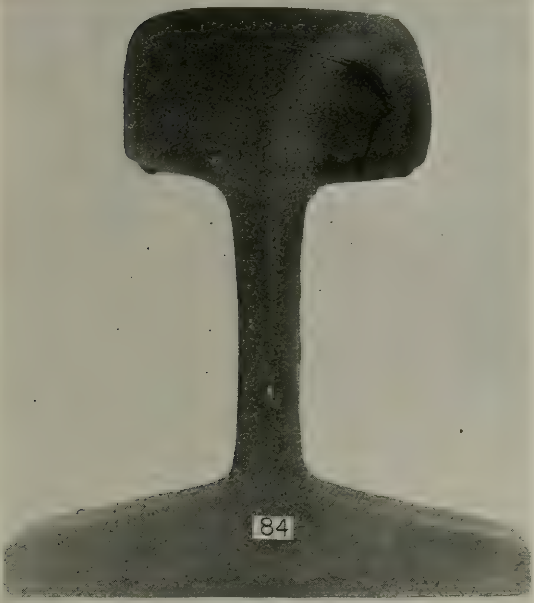

FIG. 220. RAIL 84, ETCHED SECTION SHOWING STEEL INCLUSION.

(85) SPLIT HEAD.

85-lb. P. S. O. H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 55058, Letter "G"; laid June, 1909, on straight line, gravel ballast, and removed February 15, 1910. Split head sixteen ft. in length, accompanied by flaw in metal.

C .712; Mn .83; P .038; Si .161; T. S. 119,770 lbs. per sq. in.; E. L. 72,490 lbs. per sq. in.; Elong. in 2 in., 15.5%; Red. area 22.21%.

Comments by R. W. Hunt & Company:

A consideration of the etching indicates the cause of this failure was the inclusion of soft steel. We made certain analysis on the ribbon of soft steel from the corner of the head and found results as follows:

Carbon by color .... .26 %
Phosphorus .... .093%

This analysis is practically the same as that of the tie-plate steel which was used on the ingot stools to prevent sticking. The analysis, tensile test and etching indicates that the steel aside from this inclusion was of excellent character.

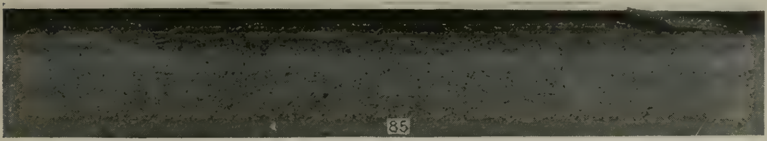

FIG. 221. RAIL 85, SHOWING SLIVERED HEAD.

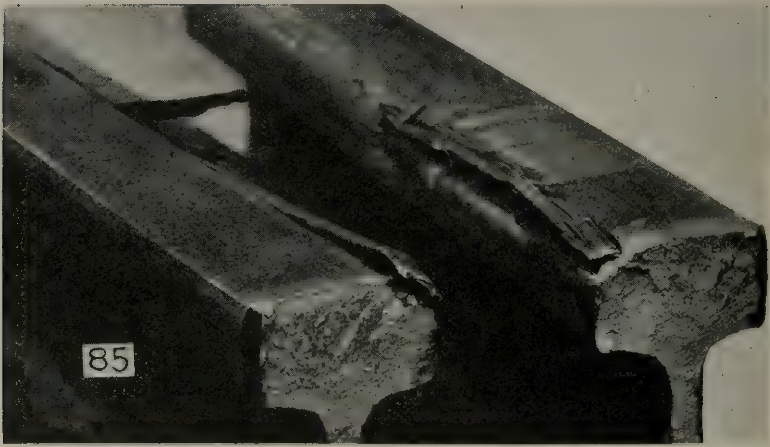

FIG. 222. RAIL 85, CUT 8 FT. 7 IN. FROM END.

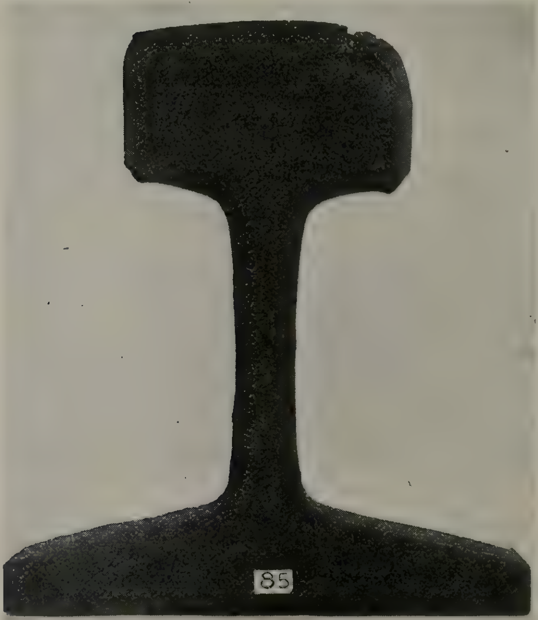

FIG. 223. RAIL 85, ETCHED SECTION SHOWING STEEL INCLUSION.

(86) SPLIT HEAD.

85-lb. P. S. O. H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 55085, Letter "C"; laid June, 1909, on straight line, gravel ballast, and removed February 15, 1910. Split head, defect being five and one-half ft. in length and seven ft. from end of rail.

C .642; Mn .66; P .030; Si .082; T. S. 105,090 lbs. per sq. in.; E. L 57,510 lbs. per sq. in.; Elong. in 2 in., 18%; Red. area 21.49%.

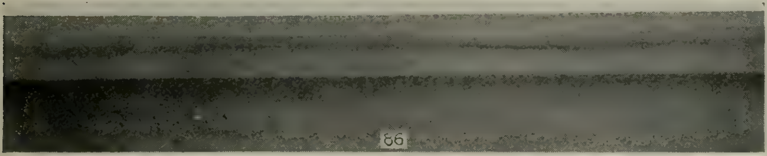

FIG. 224. RAIL 86, SHOWING SPLIT AT SIDE OF HEAD.

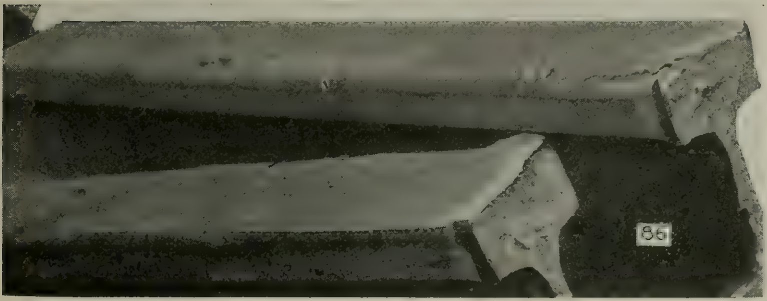

FIG. 225. RAIL 86, CUT 8 FT. 3 IN. FROM END, SHOWING SLIVERED HEAD.

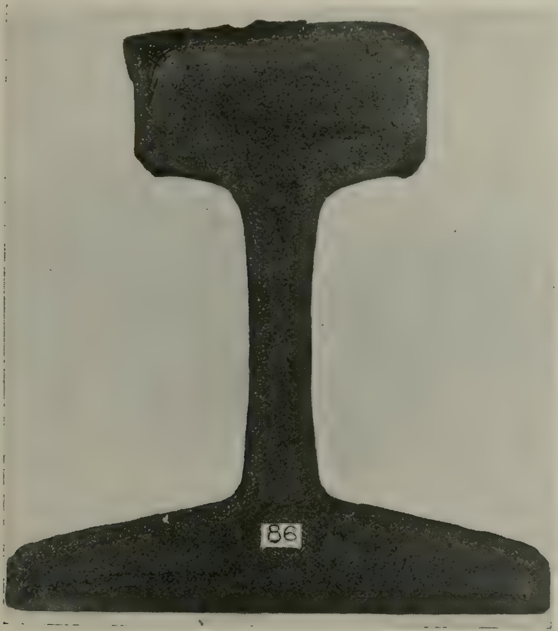

FIG. 226. RAIL 86, ETCHED SECTION SHOWING STEEL INCLUSION.

(87) SPLIT HEAD.

85-lb. P. S. O. H., made by Illinois Steel Company, Gary Works, March, 1909, Heat No. 2932, Letter "B"; laid May, 1909, on straight line, gravel ballast; removed March 4, 1910. Ten in. of split head, thirteen ft. five in. from end of rail.

C .752; Mn .76; P .045; Si .105; T. S. 121,500 lbs. per sq. in.; E. L. 72,600 lbs. per sq. in.; Elong. in 2 in., 13%; Red. area 15.52%.

FIG. 227. RAIL 87, TOP OF HEAD SHOWING SLIVER REMOVED.

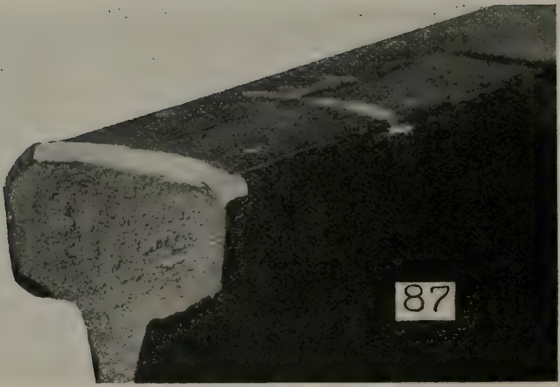

FIG. 228. RAIL 87.

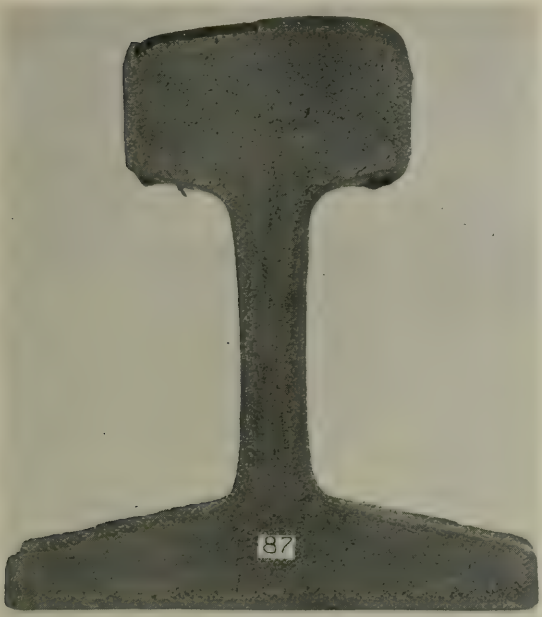

Fig. 229. Rail 87, Etched Section Showing Steel Inclusion at Top of Head.

(88) SPLIT HEAD.

85-lb. 8504, made by Illinois Steel Company, Gary Works, September, 1909, Open-Hearth, Heat No. 54348, Letter "H"; laid October, 1909, on straight line, Chillicothe gravel, and removed January 19, 1910. Battered top, rail slivering off about seven ft. at center of rail, about one-quarter in. deep toward gage side.

C .560; Mn .737; P .056; S .042; Si .13; T. S. 124,870 lbs. per sq. in.; E. L. 77,745 lbs. per sq. in.; Elong. in 2 in., 15%; Red. area 18.30%.

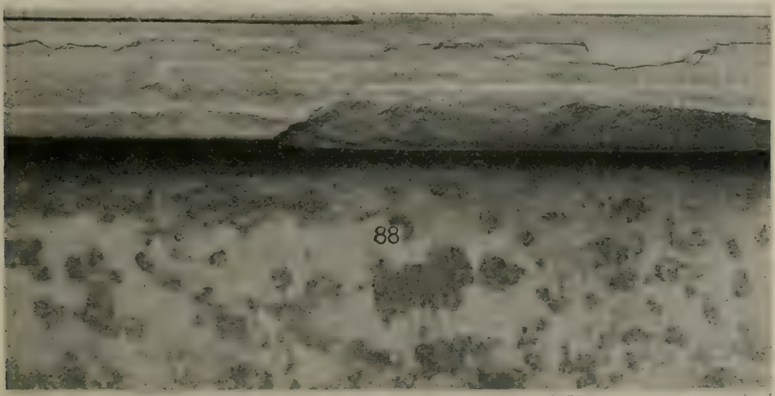

Fig. 230. Rail 88, Side View Showing Slivered Head.

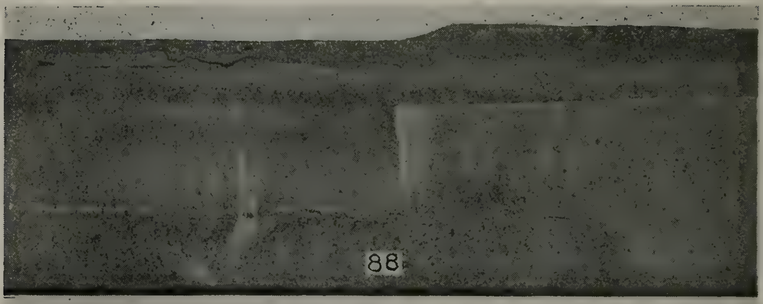

FIG. 231. RAIL 88, TOP OF HEAD SHOWING SLIVER REMOVED.

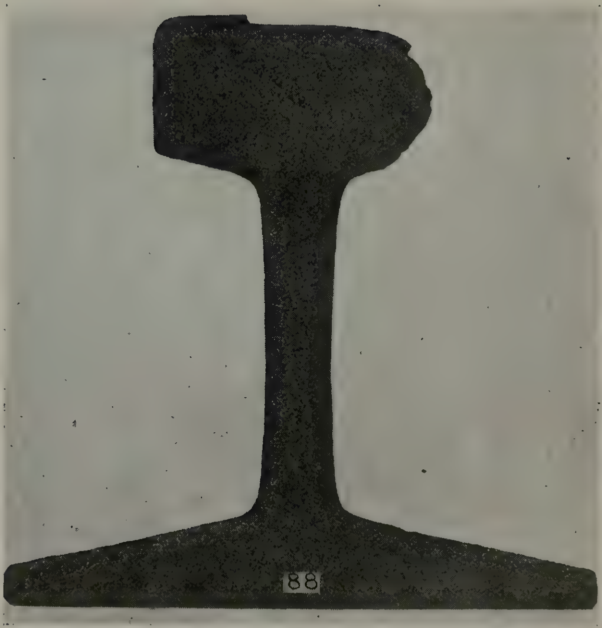

FIG. 232. RAIL 88, ETCHED SECTION SHOWING STEEL INCLUSION AT TOP OF HEAD.

(89) SPLIT HEAD.

85-lb. 8504, made by Illinois Steel Company, Gary Works, September, 1909, Open-Hearth, Heat No. 45145, Letter "E"; laid October, 1909, on straight line, gravel ballast, and removed February 10, 1910.

C .530; Mn .67; P .034; S .047; Si .12; T. S. 115,280 lbs. per sq. in.; E. L. 78,700 lbs. per sq. in.; Elong. in 2 in., 13.5%; Red. area 19.3%.

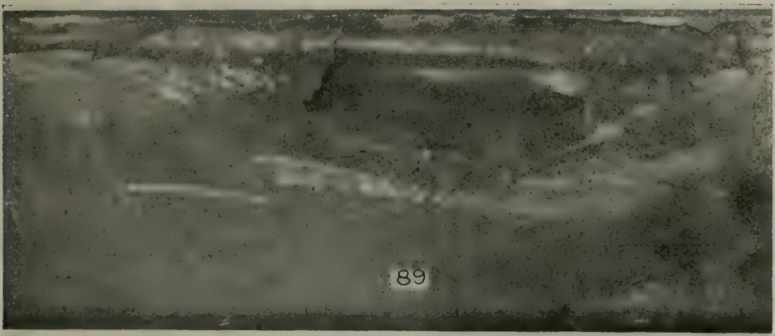

FIG. 233. RAIL 89, TOP OF HEAD SHOWING SLIVERED CONDITION.

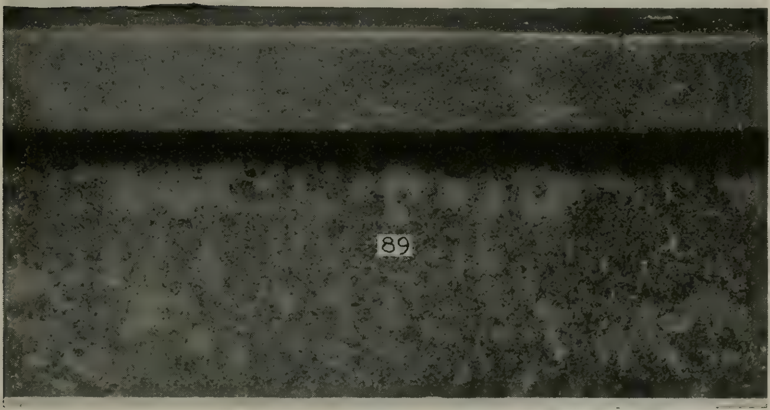

FIG. 234. RAIL 89, SIDE VIEW SHOWING SLIVERED HEAD.

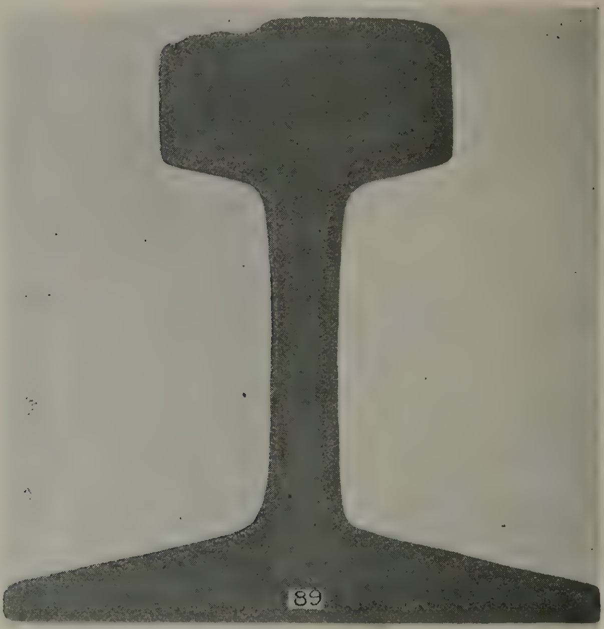

FIG. 235. RAIL 89, ETCHED SECTION SHOWING "STREAK" IN HEAD, WEB AND BASE.

(90) SPLIT HEAD.

100-lb. P. S. Bessemer, made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 2729, Letter "B"; laid April, 1909, low rail on 3-degree 3-min. curve, stone ballast, and removed March 14, 1910. About five ft. from end, flattened place about three and one-half ft. long shows crack underneath and on top of ball.

C .636; Mn .85; P .105; Si .095; T. S. 102,100 lbs. per sq. in.; E. L. 67,690 lbs. per sq. in.; Elong. in 2 in., 3.5%; Red. area 3.22%.

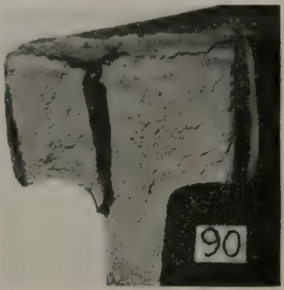

FIG. 236. RAIL 90, CUT 6 FT. 4 IN. FROM RECEIVING END.

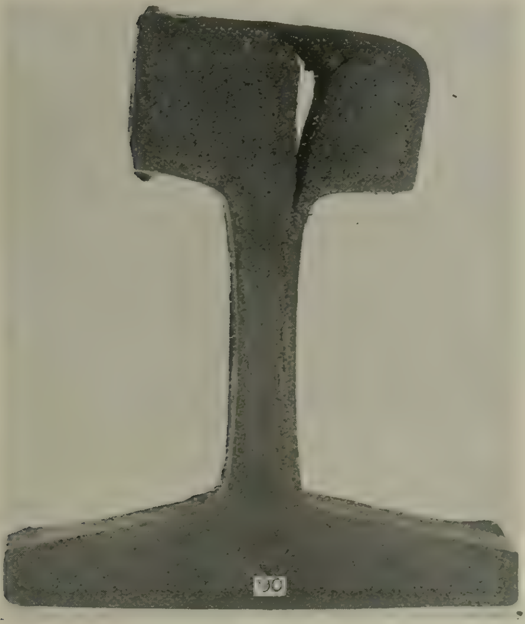

Fig. 237. Rail 90, Etched Section.

(91) SPLIT HEAD.

85-lb. P. S. Bessemer, made by Carnegie Steel Company, Edgar Thomson Works, November, 1909, Heat No. 4553, Letter "C"; laid March, 1909, low rail on 5-degree curve, limestone ballast, and removed March 12, 1910. Beginning four ft. nine and one-half in. from end, ball crushed for distance of seven ft. six in.; also cracked under ball for three ft. six in., beginning seven ft. six in. from end; split head, ball being split at end of rail.

C .771; Mn .94; P .133; Si .068; T. S. 102,030 lbs. per sq. in.; E. L. 78,840 lbs. per sq. in.; Elong. in 2 in., 1%; Red. area 1.98%. Specimen broke at fillet.

Fig. 238. Rail 91.

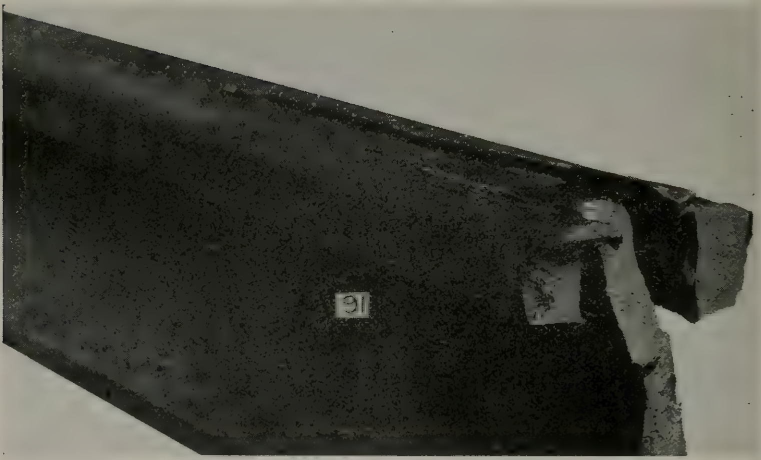

FIG. 239. RAIL 91, CUT 9 FT. 5 IN. FROM LEAVING END.

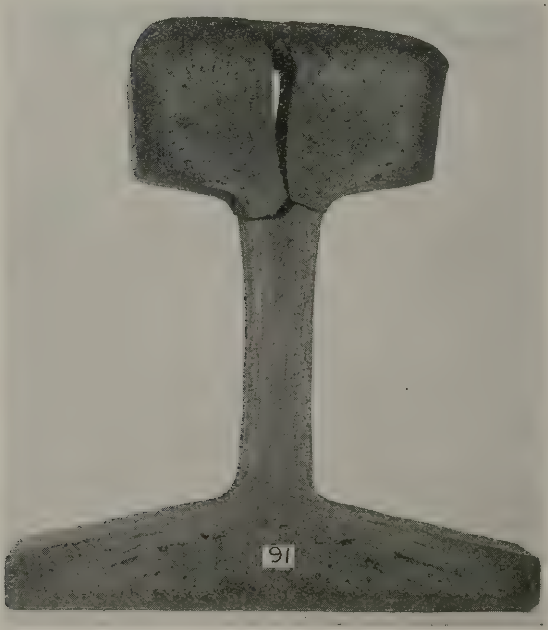

FIG. 240. RAIL 91, ETCHED SECTION.

(92) SPLIT HEAD.

85-lb. P. S. Bessemer, made by Carnegie Steel Company, Edgar Thomson Works, November, 1909, Heat No. 4452, Letter "C"; laid April, 1909, low rail on 4-degree curve, limestone ballast, and removed May 12, 1910. Web cracked, beginning one and one-half ft. from receiving end and extending for a distance of four and one-half ft.

C .752; Mn .74; P .138; Si .051; T. S. 107,280 lbs. per sq. in.; E. L. 80,340 lbs. per sq. in.; Elong. in 2 in., 3.5%; Red. area 3.16%.

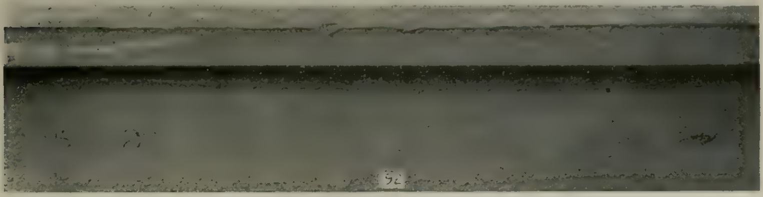

Fig. 241. Rail 92, Side View of Inside of Rail Showing Crack Under Head.

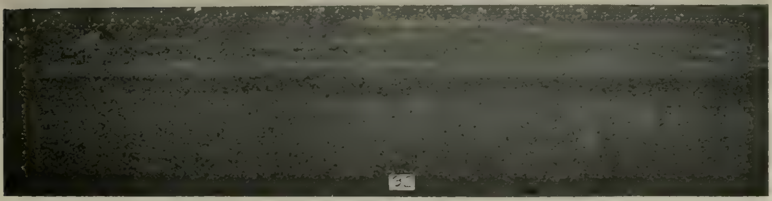

Fig. 242. Rail 92, Side View of Outside of Rail Showing Crack Under Head.

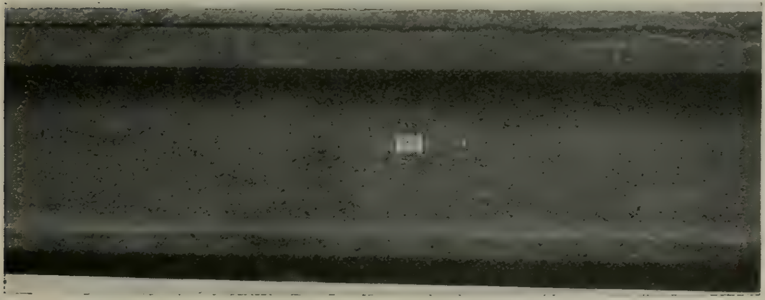

Fig. 243. Rail 92, Side View Showing Crack Under Head and Angular Crack in Web.

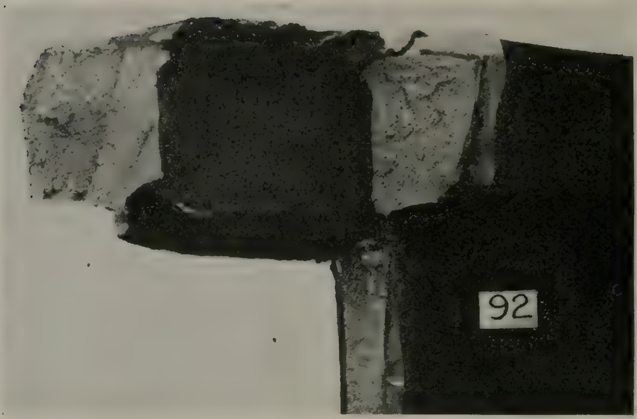

FIG. 244. RAIL 92, CUT 6 FT. FROM RECEIVING END.

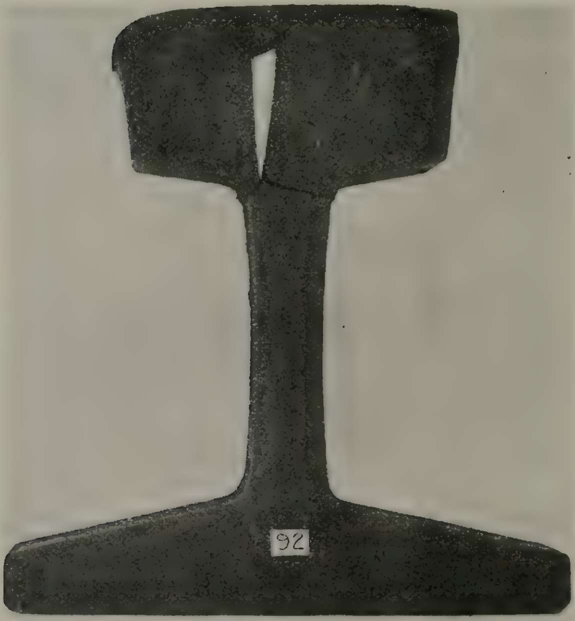

FIG. 245. RAIL 92, ETCHED SECTION.

(93) SPLIT HEAD.

100-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 7135, Letter "B"; laid October, 1909, high rail on 6-degree 12-min. curve, limestone ballast, and removed March 14, 1910. Split head, beginning at end and extending twenty in.

C .780; Mn .96; P .126; Si .077; T. S. 76,280 lbs. per sq. in.; E. L. 76,280 lbs. per sq. in.; Elong. in 2 in., 1%; Red. area 0.82%.

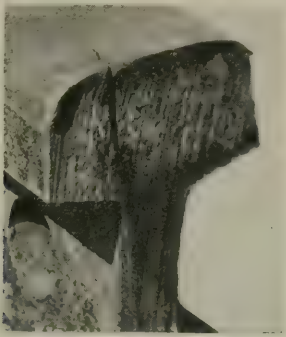

FIG. 246. RAIL 93, END OF RAIL.

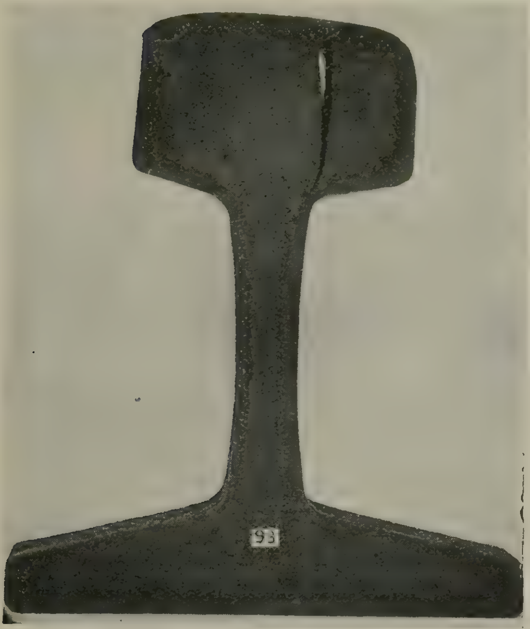

FIG. 247. RAIL 93. ETCHED SECTION.

(94) SPLIT HEAD.

100-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 7131, Letter "B"; laid April, 1909, low rail on 2-degree 45-min. 48-sec. curve, limestone ballast, and removed March 4, 1910. Split head, beginning seven in. from end and continuing a distance of two ft. three in.

C .755; Mn .81; P .113; Si .056; T. S. 88,550 lbs. per sq. in.; E. L. 82,290 lbs. per sq. in.; Elong. in 2 in., 1%; Red. area 0.00%. Specimen broke in the threads.

FIG 248. RAIL 94, SHOWING CRACK ON TOP OF HEAD.

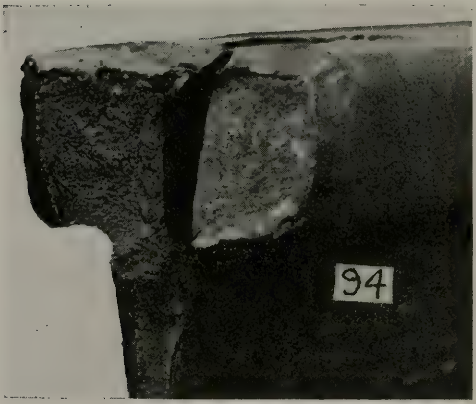

FIG. 249. RAIL 94.

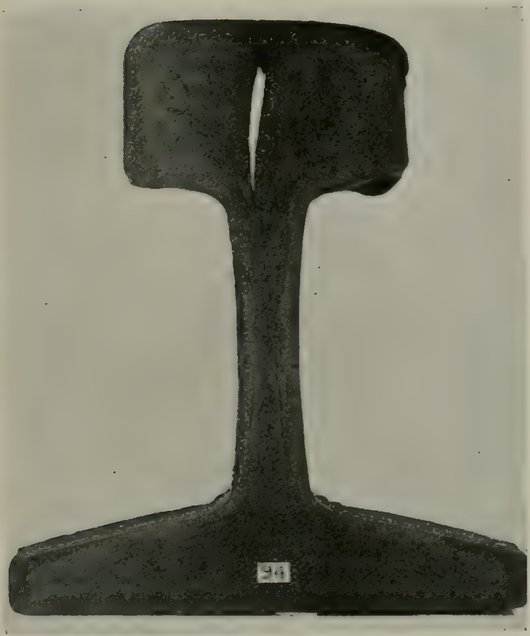

Fig. 250. Rail 94, Etched Section.

(95) SPLIT HEAD.

100-lb. P. S. Bessemer, made by Carnegie Steel Company, Edgar Thomson Works, February, 1909, Heat No. 2749, Letter "B"; laid March, 1909, low rail on 3-degree 3-min. curve, stone ballast, and removed April 13, 1910. Battered place three and one-half ft. from end, extending three ft.; also cracked twenty in. under ball.

C .576; Mn .71; P .099; Si .096; T. S. 84,200 lbs. per sq. in.; E. L. 70,350 lbs. per sq. in.; Elong. in 2 in., 2%; Red. area 2.40%.

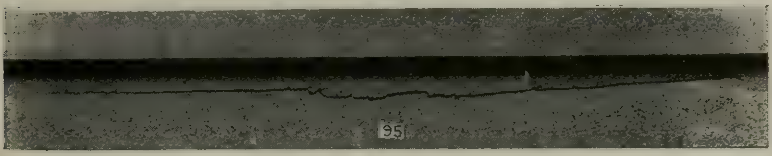

Fig. 251. Rail 95, Showing Crack in Web.

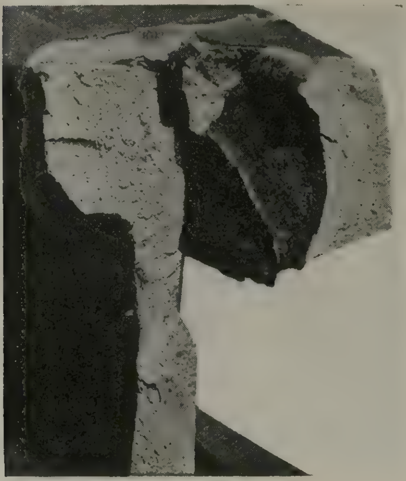

FIG. 252. RAIL 95, CUT 4 FT. 4 IN. FROM RECEIVING END.

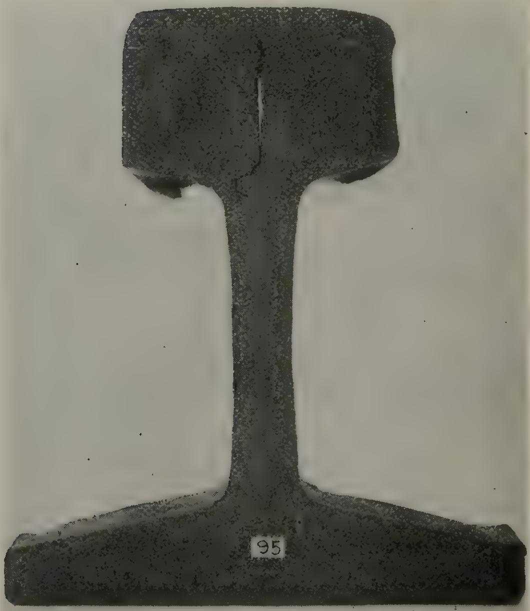

FIG. 253. RAIL 95, ETCHED SECTION.

(96) SPLIT HEAD.

85-lb. P. S. Bessemer, made by Illinois Steel Company, South Works, February, 1909, Heat No. 27406, Letter "A"; laid April, 1909, low rail on 4-degree curve, gravel ballast; removed March 16, 1910. Eighteen in. of split head, five ft. six in. from leaving end.

C .557; Mn .74; P .127; Si .135; T. S. 107,100 lbs. per sq. in.; E. L. 56,150 lbs. per sq. in.; Elong. in 2 in., 21%; Red. area 32.92%.

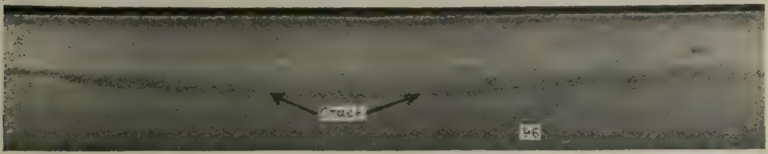

FIG. 254. RAIL 96, SHOWING CRACK UNDER HEAD.

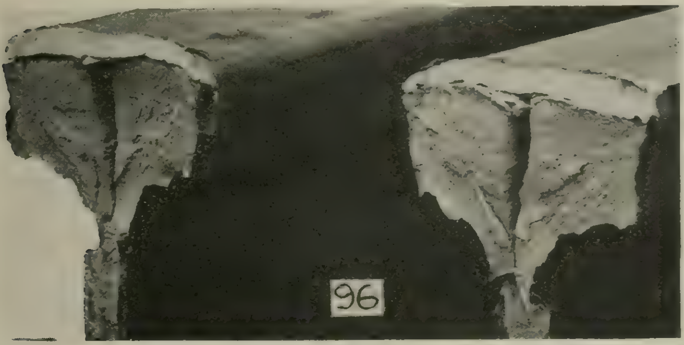

FIG. 255. RAIL 96.

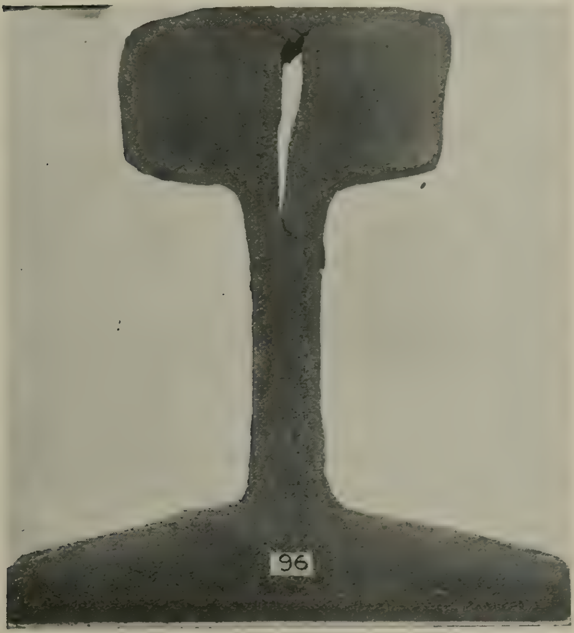

FIG. 256. RAIL 96, ETCHED SECTION.

(97) SPLIT HEAD.

100-lb. P. S., made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 7188, letter "B"; laid April, 1909, low rail on 3-degree 10-min. curve, stone ballast, and removed March 12, 1910. Split head, beginning five ft. from end and continuing a distance of eight ft.

C .712; Mn .98; P .108; Si .070; T. S. 128,170 lbs. per sq. in.; E. L. 86,250 lbs. per sq. in.; Elong. in 2 in., 13%; Red. area 17.59%.

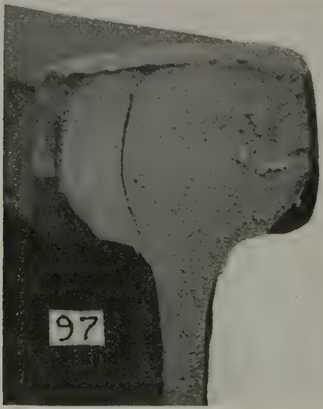

FIG. 257. RAIL 97.

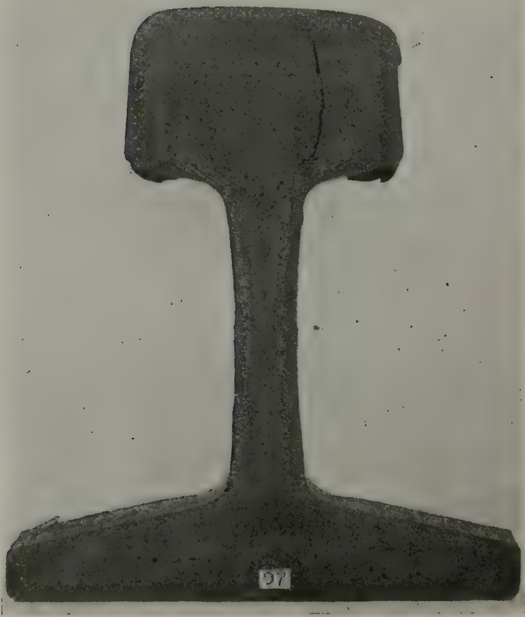

FIG. 258. RAIL 97, ETCHED SECTION.

(98) SPLIT HEAD.

100-lb. A. R. A.-"A", made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 7264, letter "B"; laid May, 1909, on straight line, gravel ballast, and removed March 5, 1910. Flaw starts one ft. two in. from end, extending four ft.; also flaw thirteen ft. from end, extending two ft. eight in.

C .888; Mn .98; P .126; Si .089; T. S. 87,220 lbs. per sq. in.; E. L. 86,810 lbs. per sq. in.; Elong. in 2 in., 0.50%; Red. area 0.41%.

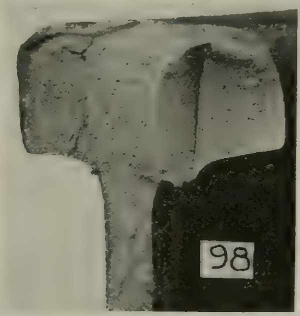

FIG. 259. RAIL 98, CUT 1 FT. 10 IN. FROM LEAVING END.

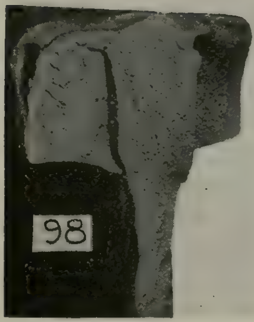

FIG. 260. RAIL 98, CUT 1 FT. 10 IN. FROM LEAVING END.

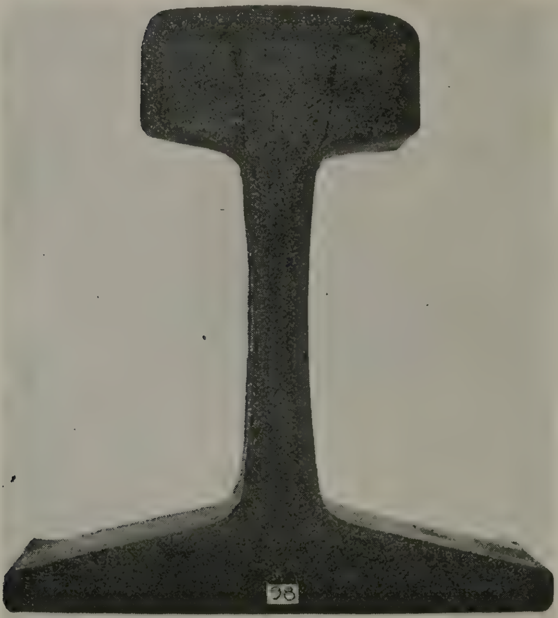

FIG. 261. Rail 98, Etched Section.

(99) SPLIT HEAD.

100-lb. A. R. A.-"A.", made by Carnegie Steel Company, Edgar Thomson Works, March, 1909; laid May, 1909, on straight line, gravel ballast, and removed March 3, 1910. Web split in two places. First split begins 8 in. from end and extends 3 ft. 9 in. Second begins 6 in. from end and extends 8 ft. 6 in.

C .766; Mn 1.02; P .143; Si .065; T. S. 89,100 lbs. per sq. in.; E. L. 89,100 lbs. per sq. in.; Elong. in 2 in., 0.00%; Red. area .76%.

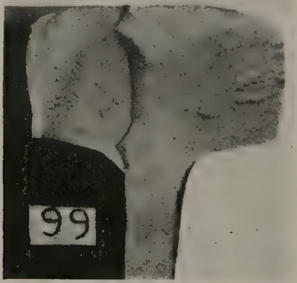

FIG. 262. Rail 99, Cut 2 ft. from Leaving End.

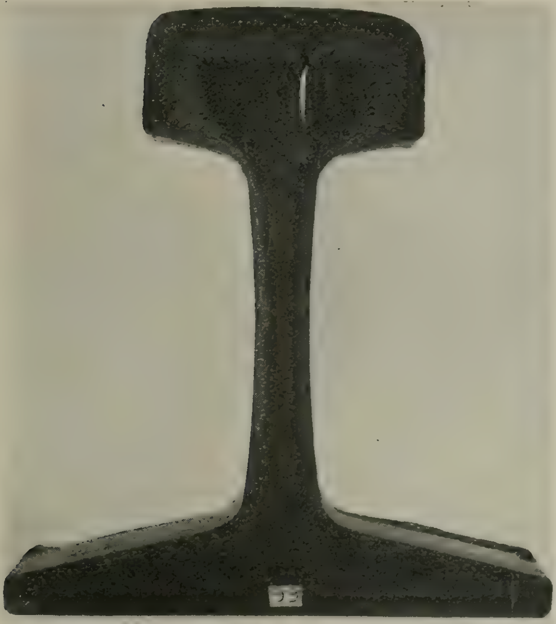

FIG. 263. RAIL 99, ETCHED SECTION.

(100) SPLIT HEAD.

100-lb. A. R. A.-"A.", made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 7323, letter "B"; laid May, 1909, high rail on 49-min. 50-sec. curve, gravel ballast, and removed March 5, 1910. Web cracked, beginning at third bolt hole and extending eighteen in.

C .644; Mn 1.00; P .106; Si .061; T. S. 116,560 lbs. per sq. in.; E. L 77,640 lbs. per sq. in.; Elong. in 2 in., 3.00%; Red. area 3.92%.

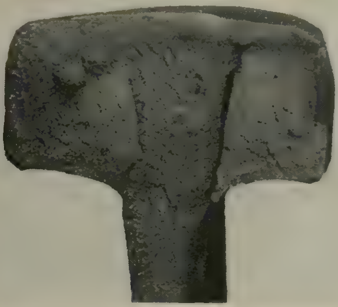

FIG. 264. RAIL 100, CUT 1 FT. 10 IN. FROM LEAVING END.

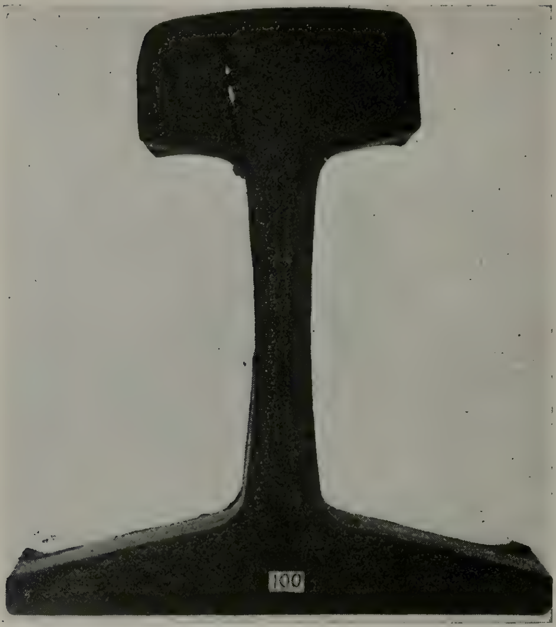

FIG. 265. RAIL 100, ETCHED SECTION.

(101) SPLIT HEAD.

100-lb. A. R. A.-"A", Bessemer, made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 7288, Letter "B"; laid November, 1909, low rail on 7-degree 45-min. curve, limestone ballast, and removed April 14, 1910. Head of rail split nine in. at end of rail.

C .864; Mn 1.01; P .157; Si .105; T. S. 107,360 lbs. per sq. in.; E. L. 78,730 lbs. per sq. in.; Elong. in 2 in., 1.50%; Red area 2.40%.

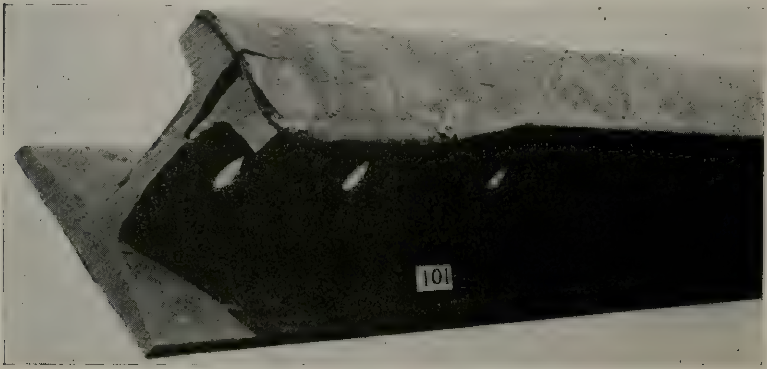

FIG. 266. RAIL 101, SHOWING SPLIT AND MASHED END.

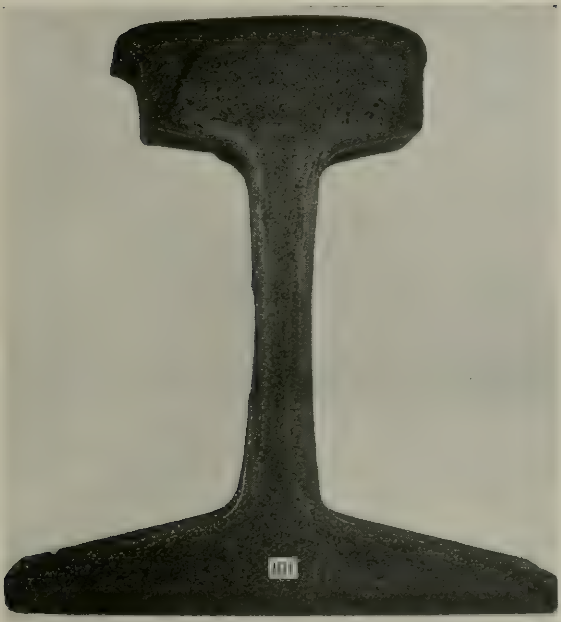

FIG. 267. RAIL 101, ETCHED SECTION.

(102) SPLIT HEAD.

100-lb. A. R. A.-"A.", made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 6748, letter "B"; laid June, 1909, high rail on 6-degree 14-min. curve, limestone ballast, and removed May 11, 1910. Beginning twelve and one-half ft. from receiving end, rail split four ft.

C .540; Mn .94; P .095; Si .072; T. S. 102,090 lbs. per sq. in.; E. L. 70,450 lbs. per sq. in.; Elong. in 2 in., 4.5%; Red. area 5.5%.

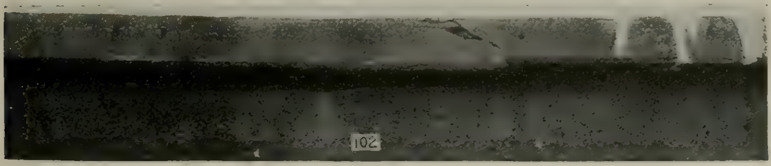

FIG. 268. RAIL 102.

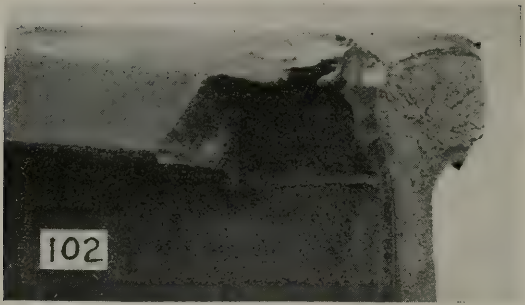

FIG. 269. RAIL 102, CUT 12 FT. 9 IN. FROM LEAVING END.

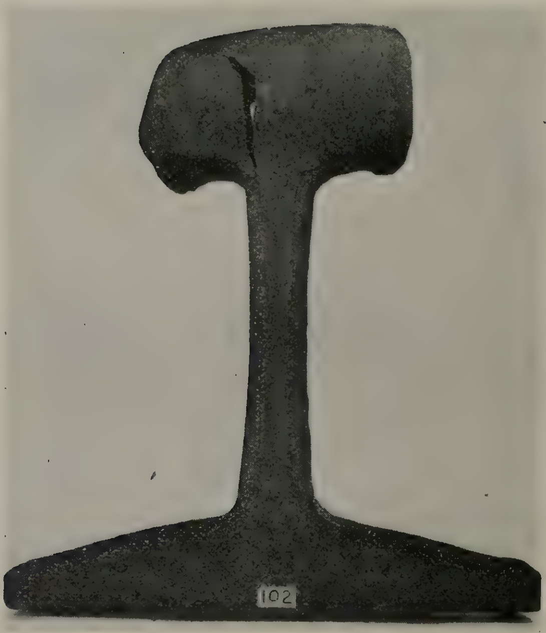

FIG. 270. RAIL 102, ETCHED SECTION.

(103) SPLIT HEAD.

85-lb. P. S. Standard, made by Carnegie Steel Company, Edgar Thomson Works, January, 1910, Bessemer steel, Heat No. 542, letter "C". Split head about ten ft. seven in. from end. This rail was never in track.

C .475; Mn .80; P .088; Si .128; T. S. 102,250 lbs. per sq. in.; E. L. 53,270 lbs. per sq. in.; Elong. in 2 in., 22.5%; Red. area 37.98%.

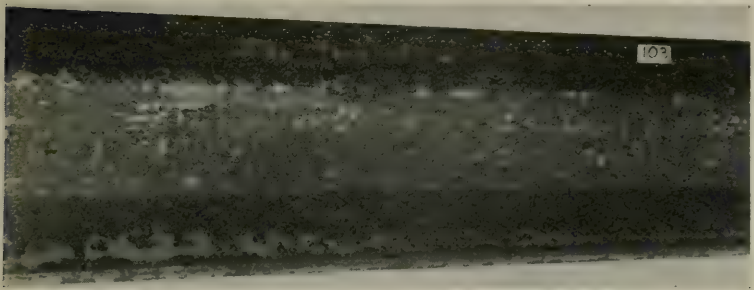

FIG. 271. RAIL 103, SIDE VIEW SHOWING FLAW IN HEAD.

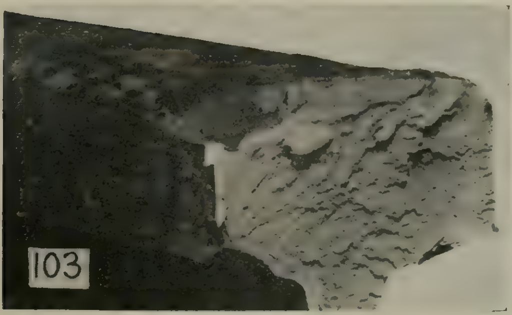

FIG. 272. RAIL 103, CUT 10 FT. 7 IN. FROM END.

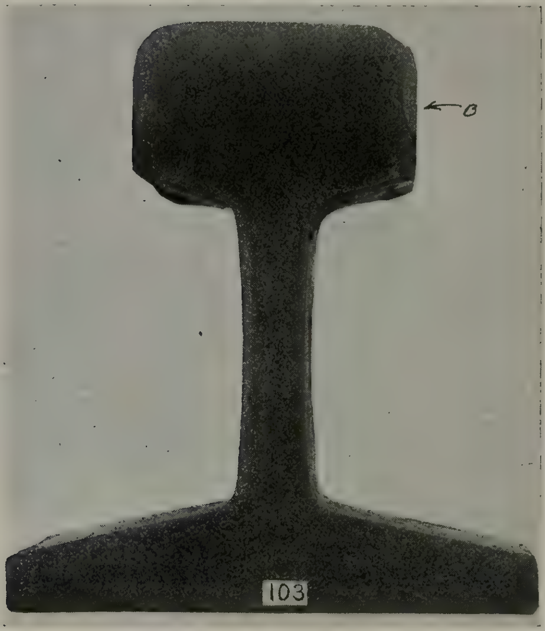

FIG. 273. RAIL 103, ETCHED SECTION.

(104) SPLIT WEB.

100-lb. P. S. Bessemer, made January, 1910, Heat No. 76981, letter "D." New rail found defective before being laid. Commencing in second bolt hole and extending twenty in. through web of rail, caused by flaw.

C .566; Mn .88; P .093; Si .072; T. S. 117,840 lbs. per sq. in.; E. L. 74,590 lbs. per sq. in.; Elong. in 2 in., 17%; Red. area 26.43%.

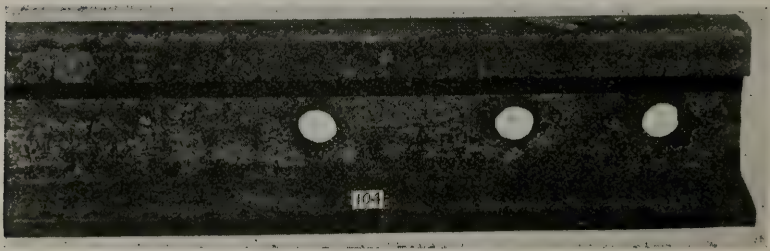

FIG. 274. RAIL 104, SHOWING CRACK IN WEB.

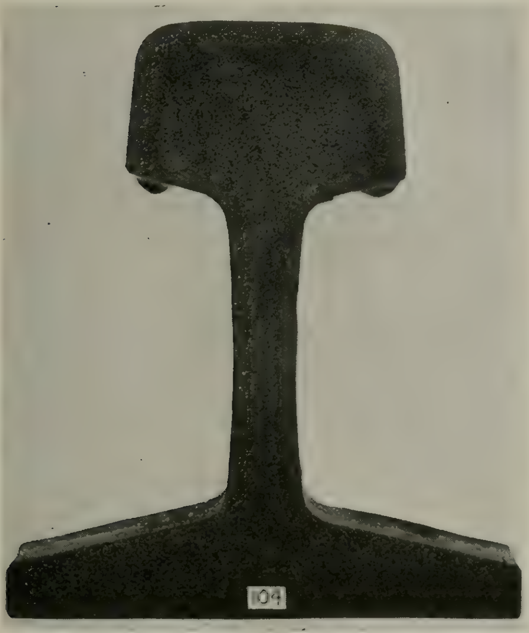

FIG. 275. RAIL 104, ETCHED SECTION.

(105) SPLIT WEB.

85-lb. P. S. Bessemer, made by Cambria Steel Company, January, 1909, Heat No. 28367, letter "C"; laid January, 1909, on straight line, stone ballast, and removed April 21, 1910. Defective joint split fourteen in.

C .517; Mn .97; P .097; Si .098; T. S. 114,010 lbs. per sq. in.; E. L. 76,460 lbs. per sq. in.; Elong. in 2 in., 18.5%; Red. area 30.11%.

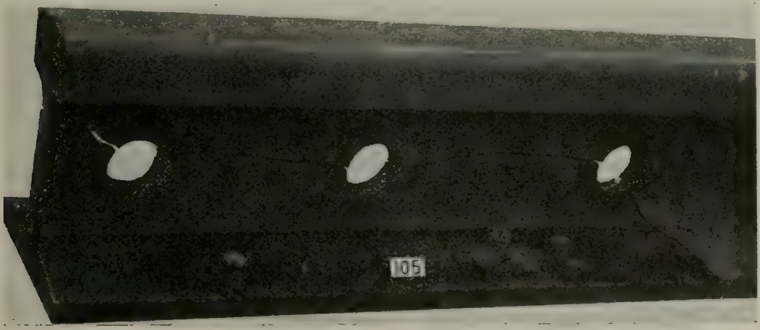

FIG. 276. RAIL 105.

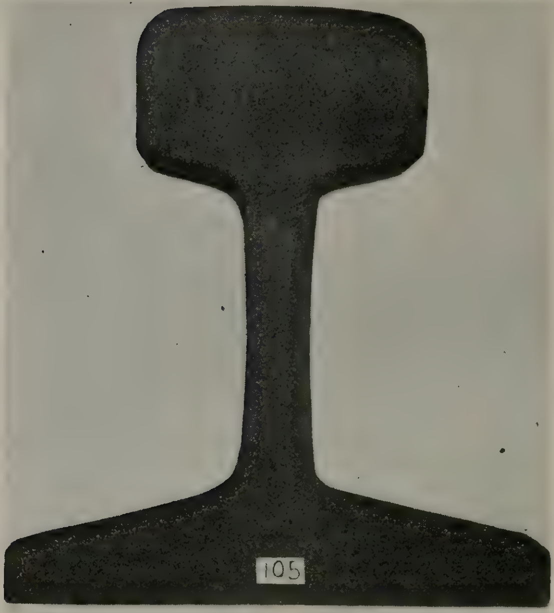

FIG. 277. RAIL 105, ETCHED SECTION.

(106) SPLIT WEB.

85-lb. P. S., made by Carnegie Steel Company, January, 1910, Heat No. 1571, letter "A"; laid May, 1910, on straight line, gravel ballast, and removed May 31, 1910. No flaws visible. Break occurred while applying angle bars and caused by blow from spike maul.

C .680; Mn 1.07; P .114; Si .128; T. S. 117,830 lbs. per sq. in.; E. L. 78,600 lbs. per sq. in.; Elong. in 2 in., 3.5%; Red. area 3.57%.

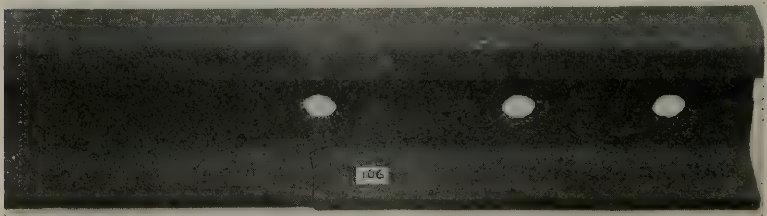

FIG. 278. RAIL 106.

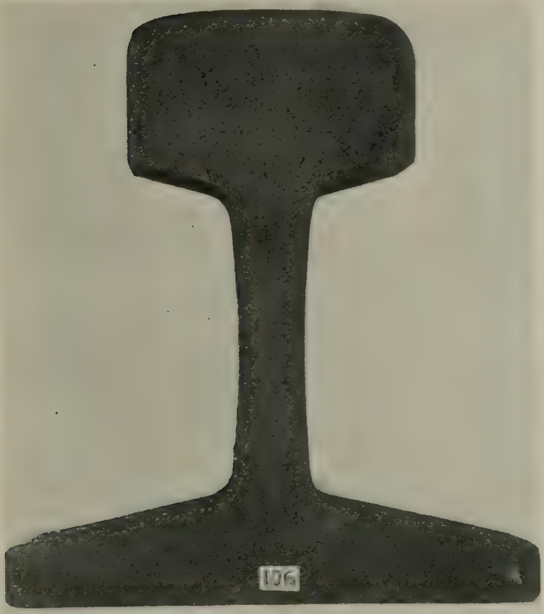

FIG. 279. RAIL 106, ETCHED SECTION.

(107) SPLIT WEB.

85-lb. P. S., made by Carnegie Steel Company, January, 1910, Heat No. 1534, letter "B"; laid March, 1910, on straight line, gravel ballast, and removed May 26, 1910.

C .637; Mn 1.07; P .083; Si .119; T. S. 109,830 lbs. per sq. in.; E. L. 86,040 lbs. per sq. in.; Elong. in 2 in., 5.00%; Red. area 5.09%.

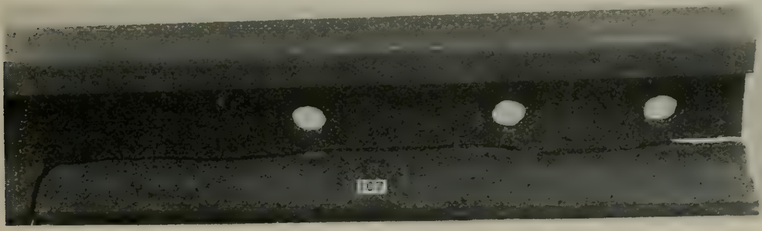

FIG. 280. RAIL 107.

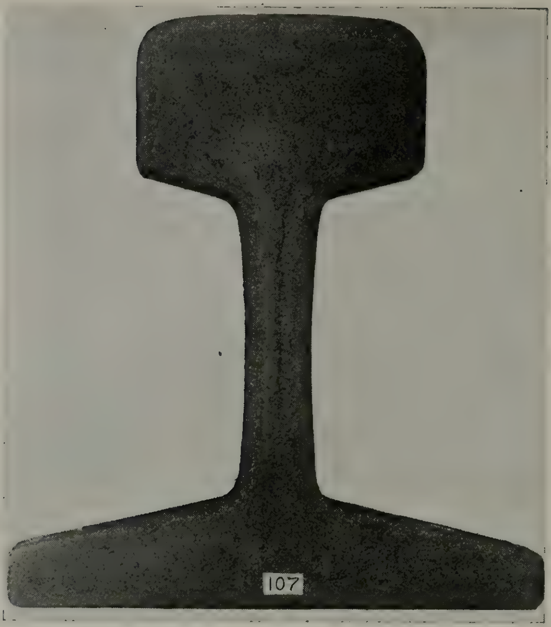

FIG. 281. RAIL 107, ETCHED SECTION.

(108) SPLIT WEB.

100-lb. P. S. O. H., made by Carnegie Steel Company, Edgar Thomson Works, March, 1909, Heat No. 54088; laid April, 1909, on straight line, gravel ballast, and removed March 10, 1910. Split twelve in. in length twenty in. from end in web rail.

C .623; Mn .63; P .034; Si .121; T. S. 124,810 lbs. per sq. in.; E. L. 79,780 lbs. per sq. in.; Elong. in 2 in., 11.5%; Red. area 16.81%.

FIG. 282. RAIL 108, SHOWING CRACK IN WEB.

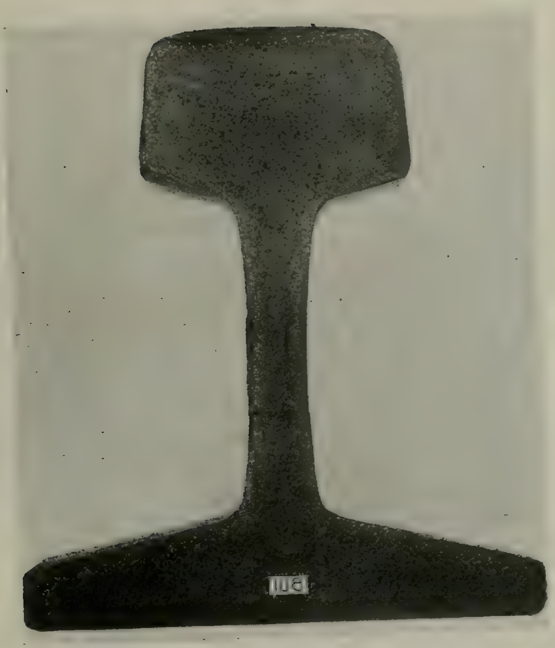

FIG. 283. RAIL 108, ETCHED SECTION.

(109) BROKEN BASE.

85-lb. A. S. C. E., made by Carnegie Steel Company, 1901; laid April, 1901, on straight line, gravel ballast, and removed April 13, 1910. Broken base caused by seam.

C .542; Mn .74; P .111; Si .075; T. S. 105,420 lbs. per sq. in.; E. L. 65,130 lbs. per sq. in.; Elong. in 2 in., 7%; Red. area 9%.

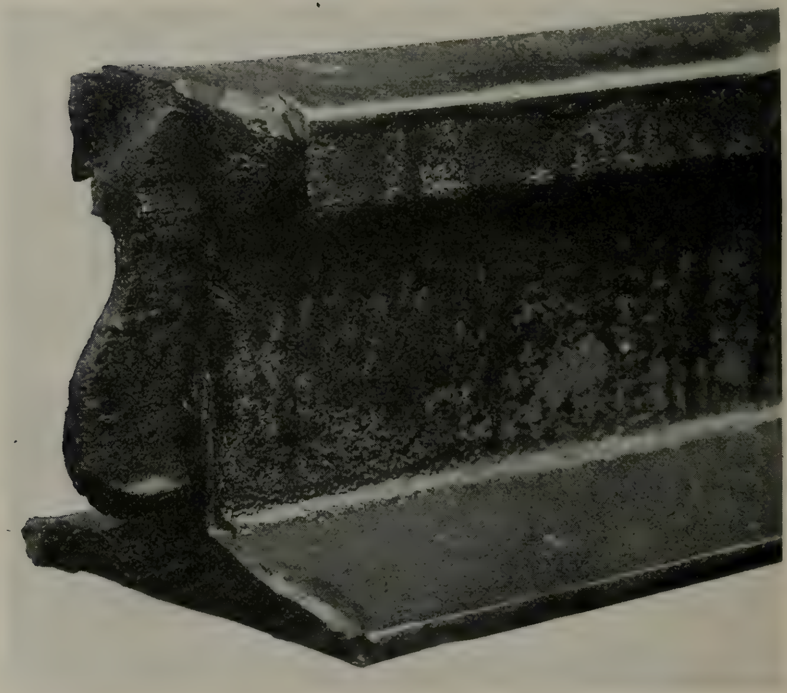

FIG. 284. RAIL 109.

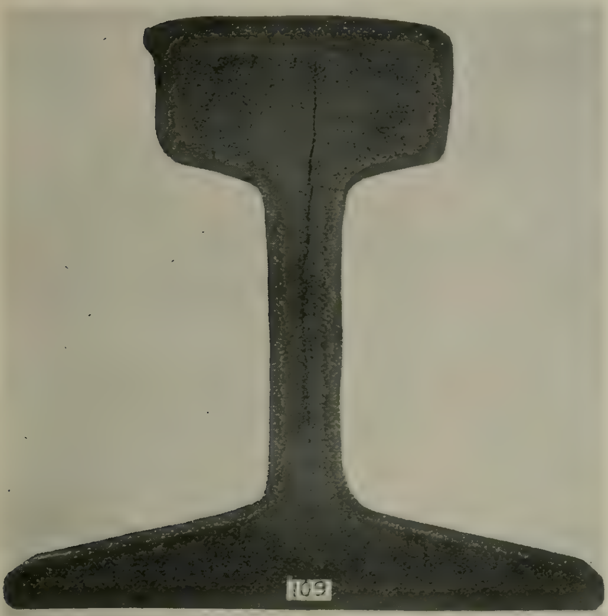

FIG. 285. RAIL 109, ETCHED SECTION.

(110) BROKEN BASE.

85-lb. P. S. Open-Hearth, made by Illinois Steel Company, Gary Works, March, 1909; laid June, 1909, high rail on 1-degree 48-min. 30-sec. curve, gravel ballast, and removed February 15, 1910:

C .602; Mn .69; P .032; Si .098; T. S. 102,520 lbs. per sq. in.; E. L. 65,860 lbs. per sq. in.; Elong. in 2 in., 20.5%; Red. area 28.54%.

Comment by R. W. Hunt & Company:

From a consideration of the etching it is apparent that the splitting off of the flange was the result of the inclusion of soft steel. The cause of this has been described in a previous report. Aside from this inclusion the steel shows excellent chemical and physical properties.

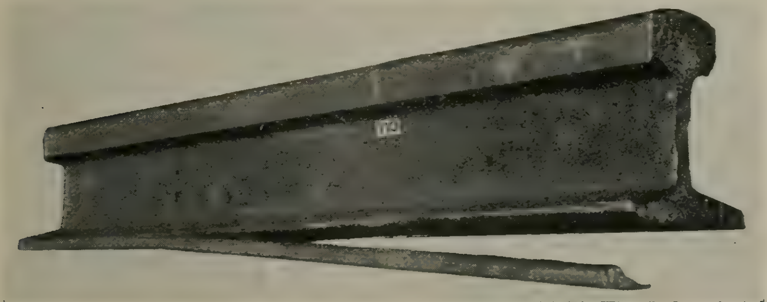

FIG. 286. RAIL 110.

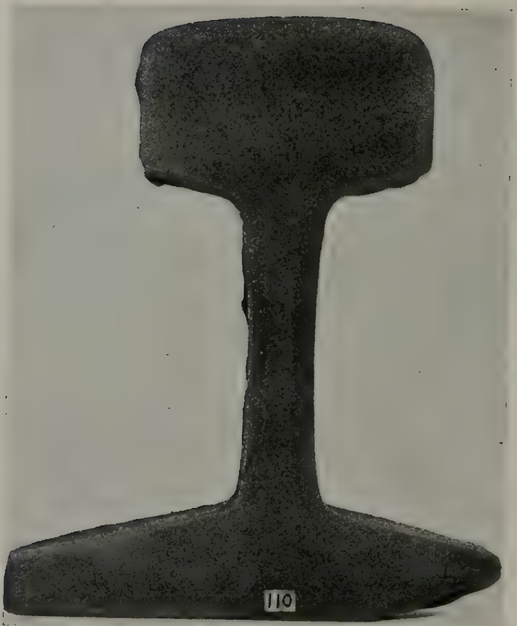

FIG. 287. RAIL 110, ETCHED SECTION.

Appendix E.

TESTS AND CONCLUSIONS BY M. H. WICKHORST.

Eleven reports have been made, covering the following subjects:

Nos. 1 and 2. Tests of Bessemer Rails—Maryland Steel Company.
No. 3. Tests of Titanium Bessemer Rails—Lackawanna Steel Co.
No. 4. Tests of Bessemer Rails—Illinois Steel Co., South Works.
No. 5. Tests of Open-Hearth Rails—Gary Works.
No. 6. Tests of Bessemer Rails—Edgar Thomson Works, Carnegie Steel Company.
No. 7. Investigation of a Split Head Rail.
No. 8. Segregation as Influenced by Fire-Clay on Ingot.
No. 9. Strength of Rail Head.
No. 10. Drop Test of Rails—Effect of Impact Energy Variously Distributed.
No. 11. Flow of Rail Head Under Wheel Loads.

Drop Test.—The height of drop that a piece of rail will stand depends upon its position in the ingot. Starting from the top of the ingot the height that is just sufficient to break the rail at first, decreases until a "brittle zone" is reached, when the rail may only stand a few feet fall of a weight of 2,000 lbs. Passing this, the allowable height rapidly increases and remains roughly uniform for the rest of the rail bar. The heights called for in various specifications vary from fifteen feet to twenty feet. Close to the top of the ingot the rail may stand such a height, but in the brittle zone, with some makes of material, the rail may stand only five feet or less. In the lower part of the ingot the rail may be able to stand heights of forty to eighty feet, or even more. Just where the brittle zone is in different materials and with different size ingots has not been determined, but an extensive investigation should now be undertaken to work this out.

Segregation.—When molten steel is poured into the ingot the different constituents that compose the liquid mass do not stay together when solidifying, but the carbon, phosphorus and sulphur tend to collect or "segregate" toward the interior and upper part of the ingot. The region of maximum segregation seems to correspond in location with the brittle zone developed by the drop test. The tests indicate that a small amount of segregation is not harmful, but the allowable limit has not been determined.

The problem of ingot making apparently consists of controlling segregation as to maximum allowable limit, and as to location in the ingot, so a small discard will always remove it.

Split Heads.—It has been shown that at least some rail failures, such as are ordinarily classed as split heads, are due to excessive segregation, which results in very fragile metal in the interior of the rail, as explained in detail in Report No. 7.

Pipes and Laminations.—Our tests show that laminations occur most frequently in rail from near the top of the ingot, but may occur in any part of the rail bar. They also show that laminations, in themselves, have no relation to the results in the drop tests. Some of the worst drop tests have shown no laminations, while the worst laminations noted have been attended by some of the best results in the drop tests.

Rolling.—Our work so far does not show very definitely the influence of such matters as speed of rolling, number of passes in reducing from ingot to rail, temperature of rolling, distribution of rail sections, etc., but they indicate that such matters are of relatively small importance.

Conclusion.—In conclusion, our work of the last nine months has shown fairly definitely that the matter of making safe rails, and in which the different rails of the lot will wear uniformly, is almost entirely a matter of making a good ingot free from excessive segregation, or of cropping off sufficient from the top to remove such excessive segregation.

TESTS OF BESSEMER RAILS—MARYLAND STEEL CO.

By M. H. WICKHORST, Engineer of Tests, Rail Committee.

REPORT No. 1.

This report covers tests of some A. R. A. type B 90-lb. Bessemer test rails made by the Maryland Steel Co. at Sparrows Point, Md., March 23, 1910. The report covers more particularly the manufacture of the rails and the results of the drop and static tests.

MANUFACTURE.

The rails were from two ingots of heat 36,289, which were given test numbers Md1 and Md2. The iron was from "A" blast furnace, whose day's burden was as follows:

El Cuero ore	346.299	tons
Nicolaieff ore	60.676	"
Sierra Morena ore	17.759	"
Coke	346.875	"
Limestone	82.366	"
Dolomite	82.266	"

The records of the ore analyses were as follows:

	El Cuero.	Nicolaieff.
Iron, natural	58.31	65.75
Iron, dried at 212 degrees F	59.52	66.86
Moisture	2.03	1.66
Silica	9.52	2.16
Manganese	.32	.13
Phosphorus	.017	.017
Sulphur	......	Trace

No nickel, cobalt, copper or chromium in either ore.

The metal from the blast furnace was poured into an 85-ton receiver, from which it was weighed and poured into an 18-ton converter. In addi-

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Reports Nos. 1 and 2, April, 1910.

tion to the hot metal from the blast furnace, cupola metal was used, which ordinarily is the same metal, but which has been run into pigs and then remelted in a cupola, this being necessary when the Bessemer plant cannot take care of all the metal from the blast furnaces. In the case of this heat, two-thirds of the cupola metal was Lebanon iron. The converter charge was as follows:

Metal from No. 2 receiver	22,500	lbs.
Cupola metal	18,000	"
Scrap steel	1,000	"

After blowing, 4,300 lbs. of spiegel was added to the converter, and 260 lbs. ferromanganese and 30 lbs. ferrosilicon added to the ladle during the pouring. The analyses of the metal in the converter before starting to blow and before the addition of scrap and of spiegel were as follows, special samples being taken for these analyses. The ladle test is also shown:

	Converter Metal.	Spiegel.	Heat Analysis.
Carbon	3.69	3.92	.51
Phosphorus	.040	.064	.046
Sulphur	.060	Trace	.060
Manganese	.24	3.96	.89
Silicon	1.33	.65	.101
Copper	.35	None	.39
Nickel or chromium	None	None	None

The copper in the converter metal came from the Lebanon iron used in the cupola metal. From the ladle the metal was poured into 20x21-inch ingot molds through a 2-inch nozzle. While pouring each ingot, about 1 lb. of ferrosilicon was added to each mold toward the end of the pour. The heat made six ingots, and the sample for the heat analysis was taken after pouring the second ingot, with results as shown in the table above. It should be stated that the various statements of mixtures used and analyses are as given me by the steel company. Ingots 4 and 5 of the pouring were selected as the ingots for test rails and were given Test Nos. Md1 and Md2, respectively. The metal set quiet. The blooms remained in the soaking pit 1 hour 25 minutes and were rolled to 7¼x7¾-inch blooms in 13 passes, the top end of the ingot forward, and turned after each two passes. The blooms were rolled directly into rails without reheating, in 11 passes, making a total of 24 passes from ingot to rail. Instead of shearing off the usual discard, I had the top of the bloom trimmed off only sufficiently to allow rolling, and then we cut off 15 feet from the top of the rail bar to represent the usual discard. These top pieces were lettered T and used for our various tests to compare with the rails from the rest of the ingot. The area of cross section in square inches in the various passes from the A. R. A. type B 90-lb. rail, Maryland Steel Co., section No. 162, is about as follows:

Operation.	No. of Pass.	Area.	Operation.	No. of Pass.	Area.
Ingot		416	Roughing	1	46.2
Blooming	1	374	“	2	34.4
“	2	336	“	3	31.3
“	3	300	“	4	23.1
“	4	260	“	5	21.5
“	5	234	“	6	17.8
“	6	205	Intermediate	7	16.0
“	7	172	“	8	15.2
“	8	150	“	9	12.3
“	9	132	“	10	9.7
“	10	117	Finishing	11	9.0
“	11	96			
“	12	74			
“	13	58			

The ingots made 5 rails in addition to the crop. The shrinkage of the rails averaged 6⅛ inches. The camber of the cold rails in 33 feet was as follows:

Rail No.	Camber.	Concave Head or Base Side.	Rail No.	Camber.	Concave Head or Base Side.
Md1-A	⅞"	Base	Md2-A	¼"	Head
Md1-B	⅜"	“	Md2-B	1"	“
Md1-C	1⅜"	“	Md2-C	1¼"	Base
Md1-D	½"	“	Md2-D	1 1/16"	“
Md1-E	¼"	“	Md2-E	¼"	“

DROP TESTS.

Drop tests were made of samples from the A, B, C and top crop rails of ingot Md2 at 15 feet drops and 18 feet drops with the head in tension and with the base in tension. The tup weighed 2,000 lbs., the supports were 3 ft. apart and the anvil weighed 10 tons, spring supported. The results of these tests are shown in Fig. 1. None of the rails broke under the first blow, and were given three or more blows, which either broke the rails or distorted them so they could not be tested farther. These tests developed some interesting information, as shown in the table below, giving some of the important results obtained.

Rail.	Height.	Elongation. Head in Tension.	Elongation. Base in Tension.
Md2-T	18	27%	19%
Md2-A	15	23 broke	15 broke
Md2-A	18	23 broke	17 broke
Md2-B	15	25	23
Md2-B	18	21	19
Md2-C	15	35	18
Md2-C	18	22	19

TEST NUMBER	HEAD OR BASE IN TENSION	HEIGHT OF DROP	NUMBER OF BLOW	DEFLECTION	Length of 1" Marks, $\frac{1}{100}$ths						REMARKS
					*1	*2	*3	*4	*5	*6	
Md2T3	Head	18'	1	2.04	107	108	108	113	110	107	
			2	3.68	108	109	112	117	119	118	
			3	5.70	109	113	117	125	127	126	Not Broken
Md2T4	Base	18'	1	1.90	105	106	107	107	106	105	
			2	3.58	108	110	112	113	112	111	Nicked and Broken. Showed Lamination 1" Long
			3	5.20	109	112	117	118	119	119	and Several Small Ones
Md2A3	Head	15'	1	1.64	104	106	106	108	108	106	
			2	3.00	107	110	112	116	114	111	Broke 4th Blow Fracture Showed Fine Grained
			3	4.30	110	115	118	122	121	116	Area Through Middle of Web. No Pipe About
			4			115	119	123	122	117	7½" of Head Broke Out
Md2A4	Head	18'	1	1 85	104	108	108	109	107	105	
			2	3.50	109	115	116	116	114	109	Broke 4th Blow Fracture Showed Fine Grained
			3	5.10	113	120	132	123	118	113	Area Through Middle of Web. No Pipe About 7½"
			4		114	120	123	123	119		of Head Broke Out.
Md2A5	Base	15'	1	1.52	102	103	105	106	105	104	Broke 3rd Blow Fine Grained Area Through
			2	2.82	1.05	106	109	111	110	109	Middle of Wed Smaller than Above 4" of Head
			3		109	110	114		115	112	Broke Out
Md2A6	Base	18'	1	1.80	104	104	106	106	105	104	Broke 4th Blow Small Fine Crystaline
			2	3.30	108	109	111	113	111	109	Streak Through Middle of Web.
			3	4 80	111	113	116	117	116	113	
			4		112		116	117	116	114	
Md2B3	Head	15'	1	1 66	103	106	107	108	107	106	Nicked and Broken, Fracture Uniform
			2	2 96	106	111	113	115	114	111	
			3	4.40	111	117	121	122	120	116	
			4	6.4	114	120	123	125	121	117	
Md2B4	Head	18'	1	1.90	107	108	104	109	107	105	Nicked and Broken Fracture Uniform
			2	3.54	113	115	116	116	113	111	
			3	5.5	115	119	121	120	115	111	
Md2B5	Base	15'	1	1 62	104	105	106	106	104	104	
			2	2 96	108	110	111	111	109	107	Not Broken
			3	4 2	113	117	117	114	112	110	
			4	5.4	118	120	120	118	114	110	
			5	7.0	120	123	123	120	115	111	
Md2B6	Base	18'	1	1.90	105	105	105	106	105	104	
			2	3.56	109	111	112	113	110	109	Not Broken Web Cracked 4th Blow
			3	5.1	114	116	116	114	112	109	
			4	7.0	118	119	119	118	114	112	
Md2C3	Head	15'	1	1.66	104	105	105	106	107	106	
			2	3.12	108	113	114	115	112	109	Not Broken
			3	4.50	113	119	124	124	119	113	
			4	6.1	118	127	131	126	126	117	
			5	7 9	120	131	135	135	129	120	
Md2C4	Head	18'	1	1 98	106	108	109	110	107	105	Deflected Sidewise Nicked and Broken
			2	3 66	112	116	117	117	114	109	Fracture Crystalline
			3	5 5	117	121	122	122	117	112	
Md2C5	Base	15'	1	1 60	103	105	105	105	105	103	
			2	2.96	107	110	110	110	109	106	Deflected Sidewise Nicked and Broken
			3	4.22	112	116	115	115	113	108	Fracture Crystalline
			4	5.7	114	118	118	118	115	110	
Md2C6	Base	18'	1	1.68	105	105	106	106	106	104	
			2	3 50	110	112	113	112	110	106	Nicked and Broken. Fracture Crys-
			3	4.92	115	117	117	116	113	110	talline
			4	6.7	117	119	119	118	115	112	

FIG. 1—DROP TESTS.

It is noticeable that the four rails broken were "A" rails, and in their case the ultimate elongation that the metal would give was obtained, while in the case of the rails not broken the full elongation that the metal would stand was not obtained. With the head in tension, the "A" rail gave a final elongation of 23 per cent., while with the base in tension the average elongation of the "A" rails was 16 per cent. The other rails, when deflected sufficiently, showed higher elongations, including also the "T," or crop rail, although this contained a large number of laminations. The "A" rail was free from pipes, but the fractures showed areas through the center of the web, from the head to the base, of a finer crystalline structure, corresponding to the carbon segregation as shown by the etching tests, which I hope to make a report on later. The "B" rails, when nicked and broken, also showed a similar area of closer structure, but not so extensive, which likewise corresponded to the carbon segregation as developed by the etching. The fractures in the "C" rails did not show this condition. The lower elongations given by the "A" rails is presumably due to the larger amounts of the various hardening elements, due to segregation. It may be well to here state that although the "A" rail showed lower elongations in the drop test, it cannot be argued that therefore it would give less wear in service. The diagram given in Fig. 2 shows the relation between ingot position and deflection after the first blow and suggests that

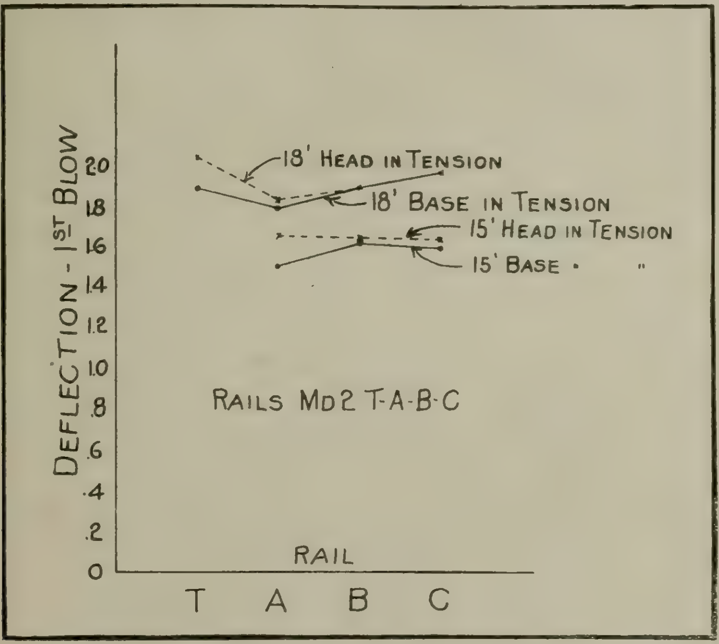


FIG. 2—DROP TEST—INGOT POSITION AND DEFLECTION.

the "A" rail is slightly stiffer than the lower rails of the ingot, although the number of tests so far made is entirely too meager to warrant any conclusion.

RELATIONS OF HEIGHT, DEFLECTION AND ELONGATION.

Some special tests were made of the "D" and "E" rails of ingot Md1 to show up the relations between height of drop, deflection and elongation. The test pieces from the "D" rail were tested with the head in tension, and those from the "E" rail with the base in tension. The results of these tests and the plotted diagram of the results are shown in Fig. 3, which should be studied closely, as they have a bearing on some questions brought up at

TEST NUMBER	HEAD OR BASE IN TENSION	HEIGHT OF DROP	DEFLECTION	LENGTH 1° MARKS $\frac{1}{100}$THS						REMARKS.
				1	#2	#3	#4	#5	#6	
MdID2	HEAD	5'	.51"	103	103	103	103	102	101	
" 3	"	10	1.10	104	105	106	106	105	104	
" 4	"	15	1.65	105	107	109	109	106	105	
" 5	"	20								CABLE BROKE
" 6	"	25								
MdIE4	BASE	5'	.74	101	102	103	103	103	103	
" 2	"	10	1.13	103	103	105	104	103	102	
" 3	"	15								TEST SPOILED
" 5	"	20	2.24	107	108	108	107	107	104	
" 6	"	25	2.67	107	108	109	109	108	107	

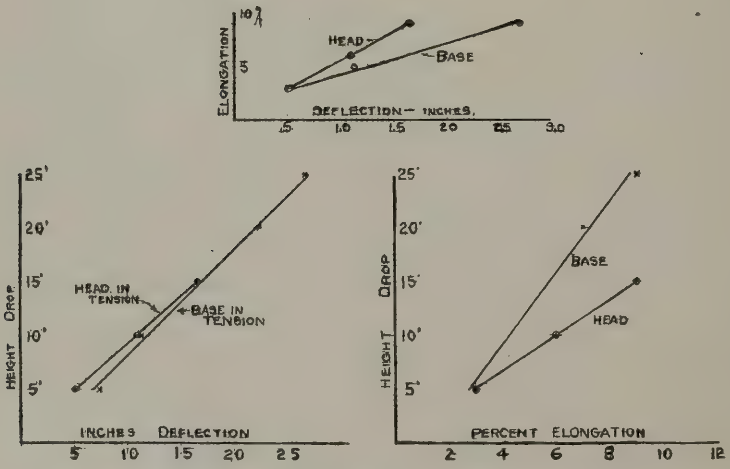


FIG. 3—DROP TESTS—RELATIONS OF HEIGHT, DEFLECTION AND ELONGATION.

the meetings of the Rail Committee. It will be noticed that for a given height of drop the deflection is about the same with head or the base in tension, but the metal at the top of the head stretches about 50 per cent. more with the head in tension than the metal at the bottom of the base when the rail is tested with the base in tension. We have also seen above that the head metal seems to stand about 50 per cent. more stretch before breaking.

STATIC TRANSVERSE TESTS.

Static transvere tests were made of pieces of rails Md1-D and Md1-E, which rails were used to make the drop tests from various heights. The span was three feet, as in the drop tests, the radii of the supports and of the compression block being 5 inches, also as in the drop tests. The results of these tests are shown in the tables below. The rails were not broken.

	Test Md1 D1. Head in Tension.		Test Md1 E1. Base in Tension.	
Load, Lbs.	Caliper.	Defl. In.	Caliper.	Defl. In.
000	9.98″		9.98″	
10,000			9.98	.00″
20,000	9.95	.03″	9.97	.01
30,000			9.95	.03
40,000	9.92	.06	9.93	.05
50,000			9.92	.06
60,000	9.89	.09	9.90	.08
70,000	9.88	.10	9.88	.10
80,000	9.86	.12	9.86	.12
90,000	9.85	.13	9.84	.14
100,000	9.81	.17	9.78	.20
110,000	9.73	.25	9.68	.30
120,000	9.60	.38	9.54	.44
130,000	9.42	.56	9.40	.58
140,000	9.21	.77	9.16	.82
150,000	8.89	1.09	8.94	1.04
160,000	8.35	1.63	8.62	1.36
167,610	7.40	2.58		
170,000			8.26	1.72
180,000			7.76	2.22
183,770			6.65	3.33

ELONGATION.

			1″ Marks.					
Test.	In Tension.	Defl.	1	2	3	4	5	6
Md1 D1	Head	2.53	1.10	1.11	1.13	1.11	1.09	1.07
Md1 E1	Base	3.33	1.08	1.09	1.11	1.11	1.10	1.07

The load-deflection diagram plotted from the table is shown in Fig. 4. Here again the deflection for a given load is about the same with the head or the base in tension, but the elongation of the outer fibers is about 50 per cent. greater with the head in tension than with the base in tension. I also show, in Fig. 5, a diagram intended to show about what proportion of the work done by the falling tup is used to deflect the test rail and how much is expended on the anvil, lost in friction, etc. Calculating the work done in the static test from the load deflection diagram, using a foot-ton as the unit of work and assuming the work done to actually bend the specimen to be the same in both the static and drop tests, it appears that about two-thirds of the work stored in the tup is used to deflect the specimen. I give this as simply an interesting calculation, although it may later prove of service.

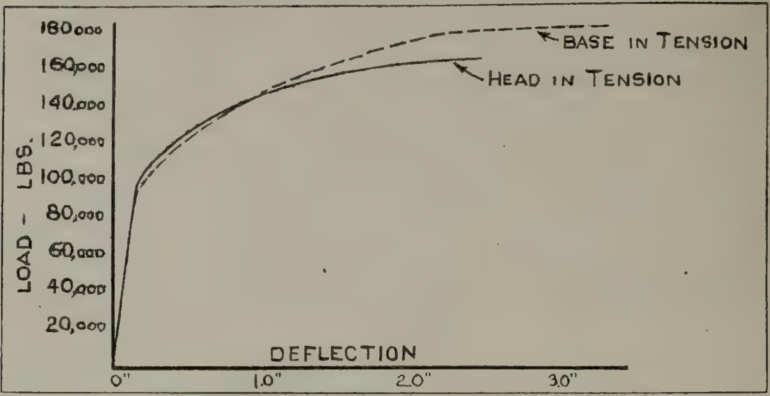


FIG. 4—LOAD-DEFLECTION DIAGRAM.

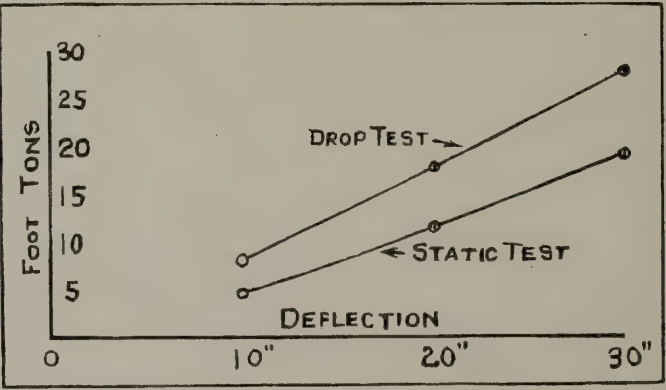


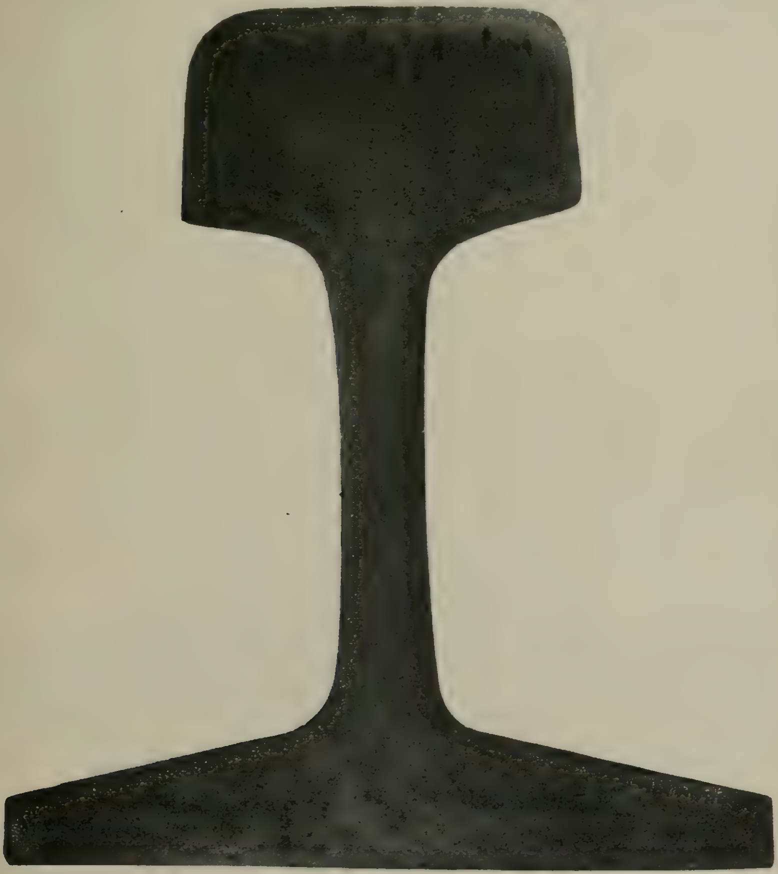
FIG. 5—RELATION OF WORK DONE IN BENDING RAIL IN DROP AND STATIC TESTS.

REPORT No. 2.

Report No. 1 covers some tests concerning A. R. A. type B 90-lb. Bessemer rails made by the Maryland Steel Co., and I now give a further report concerning these rails, covering the results of the etching tests, chemical analyses and tests with the reciprocating machine.

ETCHING TESTS.

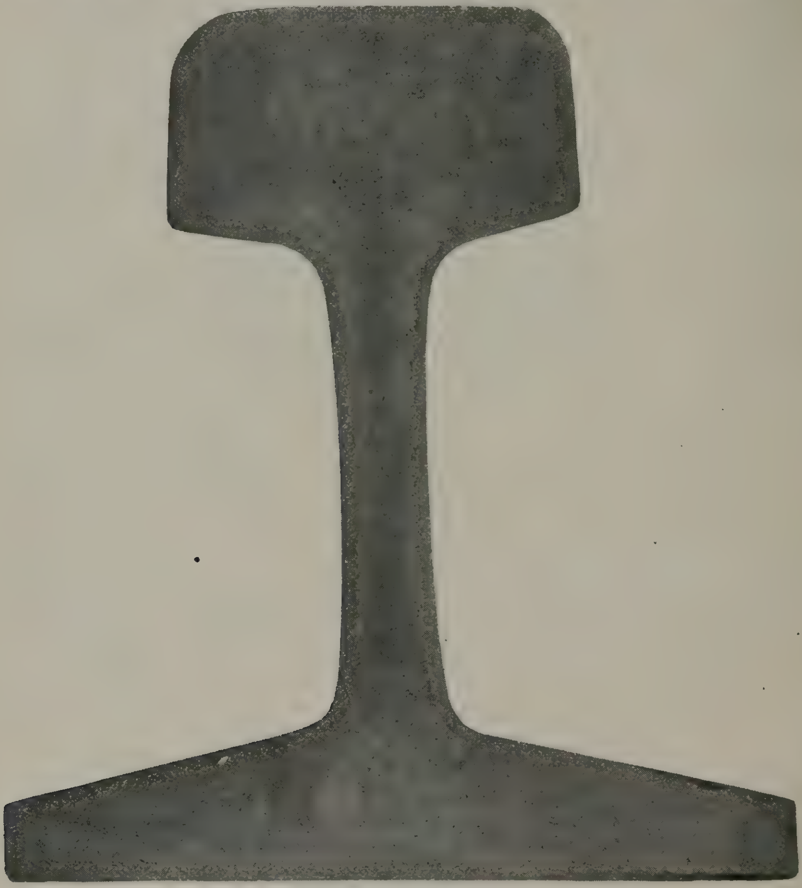
Sections of one inch were cut from near the top ends of each rail of the ingot, including also the top or crop rail given the letter "T." These sections were etched with a solution of iodine in alcohol, to show up the segregated areas. The top of the crop rail showed spots of segregation



Md. 2 T 2

Fig. 6—Top End of Crop Rail, Etched with Iodine in Alcohol.

distributed over the whole section. The top of the "A" rail showed a concentration of the segregation, mostly down along the middle of the web, extending from well into the head down to near the base, with some spots of segregation distributed over the rest of the section. The "B" rail showed a small streak of segregation down through the web. The "C" rail showed a few spots, the "D" rail almost no spots of segregation, and the "E," or bottom rail, showed no segregation whatever. Figs. 6 and 7 show etchings of the "T" and "A" rails, the important feature being the strong concentration of the segregation in the web and lower third of the head of the "A" rail. The fractures of the "A" rail in the drop tests, as stated in my previous report, showed no pipes or laminations, but



Md. 2 A 2

FIG. 7—TOP END OF A RAIL, ETCHED WITH IODINE IN ALCOHOL.

showed crystalline areas down through the middle of the web of finer structure than the rest of the broken surface, while the lower rails of the ingot showed uniform fractures.

CHEMICAL ANALYSES.

Analyses were made of the "A," "B" and "C" rails, the drillings being taken from the sections used for etching, and two samples being taken from each section. One sample was taken with a $\frac{3}{16}$-inch drill along the middle of the web, from a point about one-third way up into the head to just below the center of the rail. This sample would represent the segregated metal. The other sample was taken near the upper corner of the head with a ¾-inch drill and would represent the normal metal of the rail. The results of the analyses are shown in the following table:

Test No.	Location.	Carb.	Phos.	Sul.	Man.	Silicon.	Copper.
Md2-A2	Head	.54	.049	.058	.93	.100	.37
Md2-A2	Web	.63	.096	.129	.93	.104	.38
Md2-B2	Head	.52	.048	.065	.89	.098	.34
Md2-B2	Web	.55	.051	.076	.90	.104	.35
Md2-C2	Head	.56	.049	.059	.87	.103	.39
Md2-C2	Web	.53	.049	.061	.90	.104	.38
Heat Analysis		.51	.046	.060	.89	.101	.39

The metal contained no nickel, cobalt or chromium. It will be noted in the above table that the carbon, phosphorus and sulphur segregated in the "A" rail and that the manganese, silicon and copper showed no segregation in any of the rails. The "B" rail also shows a slight segregation of the sulphur. The increase of the segregated elements in the web of the "A" rail over the amounts in the upper corner of the head show percentages as in the following table:

	Carbon.	Phosphorus.	Sulphur.
Head	.54	.049	.058
Web	.63	.096	.129
Increase	17%	96%	122%

RECIPROCATING MACHINE.

The Maryland Steel Co. has at Sparrows Point a machine intended to represent the condition of very heavily loaded equipment rolling over the rail and to test the capacity of the head of the rail to withstand crushing and splitting. It consists of a bed to which the rail can be fastened. A 33-inch car wheel rests on the rail, and a heavy load can be applied to the axle of the wheel by means of levers which multiply the free weight by 600 times. The rail is moved back and forth under the loaded wheel by means of a planer bed, up to a maximum stroke of about 6 ft. Pieces one foot long were cut from the top of each rail of Ingot Md2, namely, the "T," "A," "B," "C," "D" and "E" rails, and set up with a load of 90,000 lbs. on the wheel. The machine was run for a day, making 1,910 double strokes or 3,820 movements of the loaded wheel over each rail, but there was no noticeable effect except to flatten the surface of the rail. This test was then stopped, as it seemed hopeless to get results in a reasonable time. Then to see what results might be expected with a lightweight rail with a thin head, I had the machine set up with three pieces, each 12 inches long, of 70-lb. A. S. C. E. rail from stock, with a load of 90,000 lbs. applied to the wheel axle. The wheel was run for more than a day over one of the pieces, making 3,963 double strokes, or 7,926 movements of the wheel over the rail, and here again the only effect was to flatten the top surface of the rail and widen the top part of the head .02 of an inch. It seems that in order to get results in reasonable time, it will be necessary to make the test more severe by the application of a heavier load or other means. I would particularly like to have the members of the committee write out their suggestions concerning this matter.

Finally, I wish to acknowledge the kind treatment and help given me by the officers of the Maryland Steel Co. in starting off the line of tests we have undertaken to make.

TESTS OF TITANIUM BESSEMER RAILS—LACKAWANNA STEEL CO.

By M. H. WICKHORST, Engineer of Tests, Rail Committee.

This report covers tests of some titanium bessemer rails, 90-lb. A. R. A. type B, made at the Lackawanna Steel Company, at Buffalo, N. Y., on April 23, 1910, Lackawanna Steel Co. pattern 9032.

MANUFACTURE.

The test rails were from three ingots of heat 20,989, and the ingots were given test numbers L1, L2 and L3, each ingot furnishing four rails, A, B, C and D. The ore was Lake Superior ore. The iron from the blast furnace was poured into a 225-ton mixer, from which it was weighed and poured into a converter. Scrap was added to the converter and the metal held for 3¼ minutes after blowing. The metal was then poured into the teeming ladle, the ferro-titanium being shoveled in at the same time. The metal was then held for 3¾ minutes and poured into the molds. The amounts used were as follows:

Mixer Metal	26,600 lbs.
Scrap	800 lbs.
Spiegel	2,760 lbs.
Ferro-titanium	84 lbs.

Special samples were taken of the mixer metal and the spiegel, and gave the following results on analysis:

	Carbon.	Phos.	Sulph.	Mang.	Sil.
Mixer metal	3.95	.091	.045	.70	2.26
Spiegel	4.37	.075	.006	13.87	1.77

The ferro-titanium addition was .3%, and as it contained 10% titanium, the titanium added amounted to .03%. No titanium was later found in the steel.

The metal was poured through a 1½-inch nozzle, making 6 ingots and 8½ minutes being used for the pouring. About one pint of coal tar had

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been poured into each mold. The sample for heat analysis was taken while pouring the second ingot. The ingots for the test rails were the third, fourth and fifth ingots and averaged 4,587 lbs. The ingots were in the soaking pit 2 hours and 15 minutes. They were 18½x18½ inches, rolled to 8x8 blooms in 6 passes and finished in 9 passes, making a total of 15 passes from ingot to finished rail. The area was reduced from 334.5 sq. in. to 9.14 sq. in., or a reduction of 37 times. The operations and hot areas as furnished by the steel company of their pattern 9032 are as follows:

		Hot Area.
Ingot 18½x18½ inches.		334.50 sq. in.
No. 1 Blooming	1 pass	243.75 sq. in.
No. 2 Blooming	1 pass	190.25 sq. in.
No. 3 Blooming	No. 1	141.75 sq. in.
	No. 2	107.00 sq. in.
	No. 3	78.82 sq. in.
	No. 4	64.20 sq. in.
Roughing	No. 1	48.28 sq. in.
	No. 2	38.71 sq. in.
	No. 3	30.00 sq. in.
	No. 4	25.53 sq. in.
First Finishing	No. 1	20.75 sq. in.
	No. 2	14.59 sq. in.
Sec. 9032	No. 3	10.83 sq. in.
	No. 4	9.57 sq. in.
Second Finishing	Fin. Groove	9.14 sq. in.

The discards of the three test ingots were as follows:

	Top.	Bottom.	Total.
L1	9.3%	3.8%	13.1%
L2	10.6%	3.6%	14.2%
L3	11.2%	4.2%	15.4%

The camber of the hot rails immediately after leaving the hot cambering rolls was measured on one rail and found to be 4½ inches. The camber of the cold rails was as follows in 33 feet, except where a shorter length of rail is noted:

Rail.	Camber.	Concave, Head or Base Side.	Rail.	Camber.	Concave, Head or Base Side.
L1 A	½	Head	L2 C	¾	Head
L1 B	½	Head	L2 D	¼	Base 28 ft.
L1 C	1⅛	Head	L3 A	⅝	Head
L1 D	⅛	Base	L3 B	¾	Head
L2 A	¾	Head	L3 C	½	Head
L2 B	⅞	Head	L3 D	1⅜	Base 28 ft.

Pieces were cut from each of the four rails of ingot L1 for special tests in order as follows:

18 inches, chemical analyses, etching and tensile tests.
4½ feet, drop test, head in tension.
4½ feet, drop test, base in tension.
4½ feet, bending test, head in tension.
4½ feet, bending test, base in tension.

CHEMICAL ANALYSES.

Two samples for analysis were taken from each rail, one near the upper corner of the head to represent the normal metal of the rail, and the other

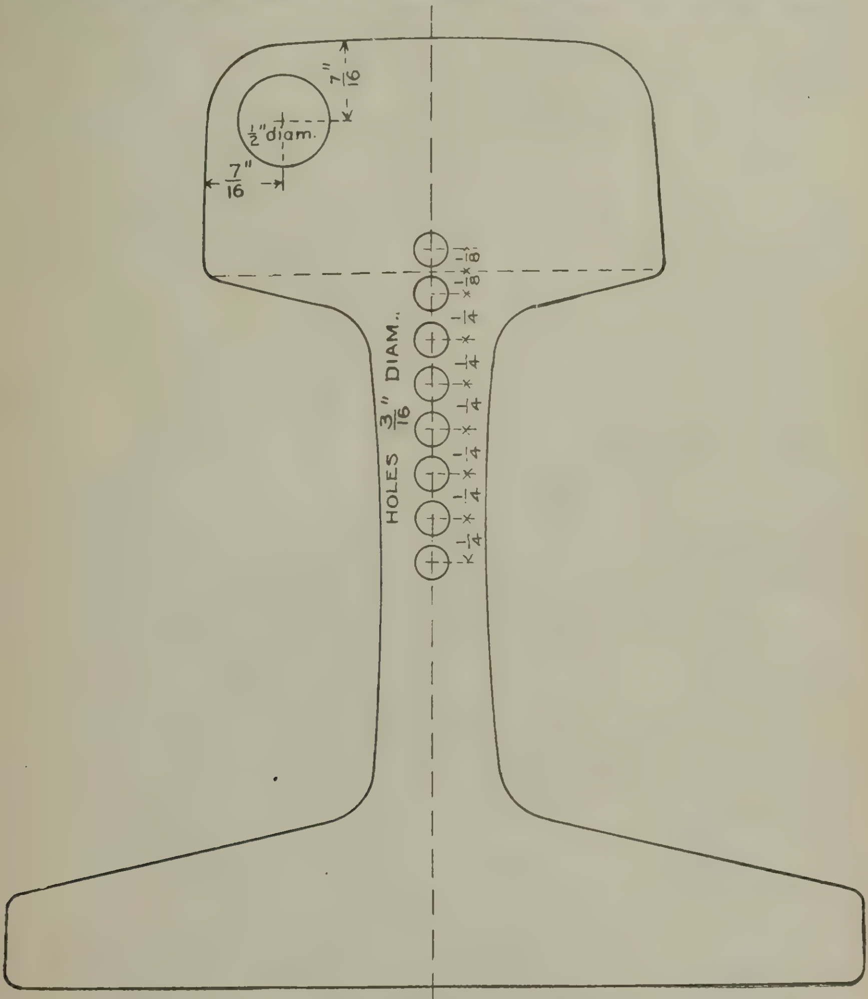


Fig. 1—Samples for Analysis.

from the web to represent the segregated metal, if present, the borings being taken as shown in Fig. 1. The samples were taken from the top end of the rail. The result of these analyses and of the ladle analysis representing the heat are shown in the following table:

		Carbon.	Phos.	Sulph.	Mang.	Sil.
L1 A1	head	.49	.098	.048	.89	.14
	web	.51	.096	.039	.90	.12
L1 B1	head	.50	.098	.046	.90	.13
	web	.57	.108	.046	.91	.12
L1 C1	head	.50	.097	.043	.91	.12
	web	.50	.093	.040	.88	.13
L1 D1	head	.52	.097	.045	.90	.13
	web	.45	.086	.038	.89	.13
Heat analysis		.48	.091	.040	.90	.14

The above figures show no concentration of any of the elements into the middle of the rail, except that the web of the B rail shows a slight segregation of the carbon and phosphorus. The results from the web of the D rail show a little lowering or "negative segregation" of carbon, phosphorus and sulphur. This is interesting and seems to show that the selective freezing of the high melting constituents drives the segregating elements upward from the bottom of the ingot as well as inward. The metal along the sides and bottom of the mold freezes at once and is practically the same metal as poured. Inside of this would be metal solidifying more slowly where the high melting constituents could freeze out, while the lower melting material containing carbon, phosphorus and sulphur would tend to concentrate in the portion still remaining liquid. The top of the C rail, which would be about the middle of the ingot, shows about the same analysis in the head and the web. Roughly, then, below the middle the axis of the ingot shows a little negative segregation, while above the middle there is a little positive segregation reaching a maximum about the top of the B rail.

ETCHING.

Sections were cut from near the top of each rail, polished with fine emery and etched with a 50% dilution of hydrochloric acid. The etched surfaces are shown in Figs. 2, 3, 4 and 5. The A rail shows no "pipe," but shows some small laminations. The B rail shows a very even structure and shows one small lamination at the junction of the head and web. The C and D rails show "cores" which the analyses show to be slightly lower in the hardening elements, especially in the D rail, than the other portions of the rail.

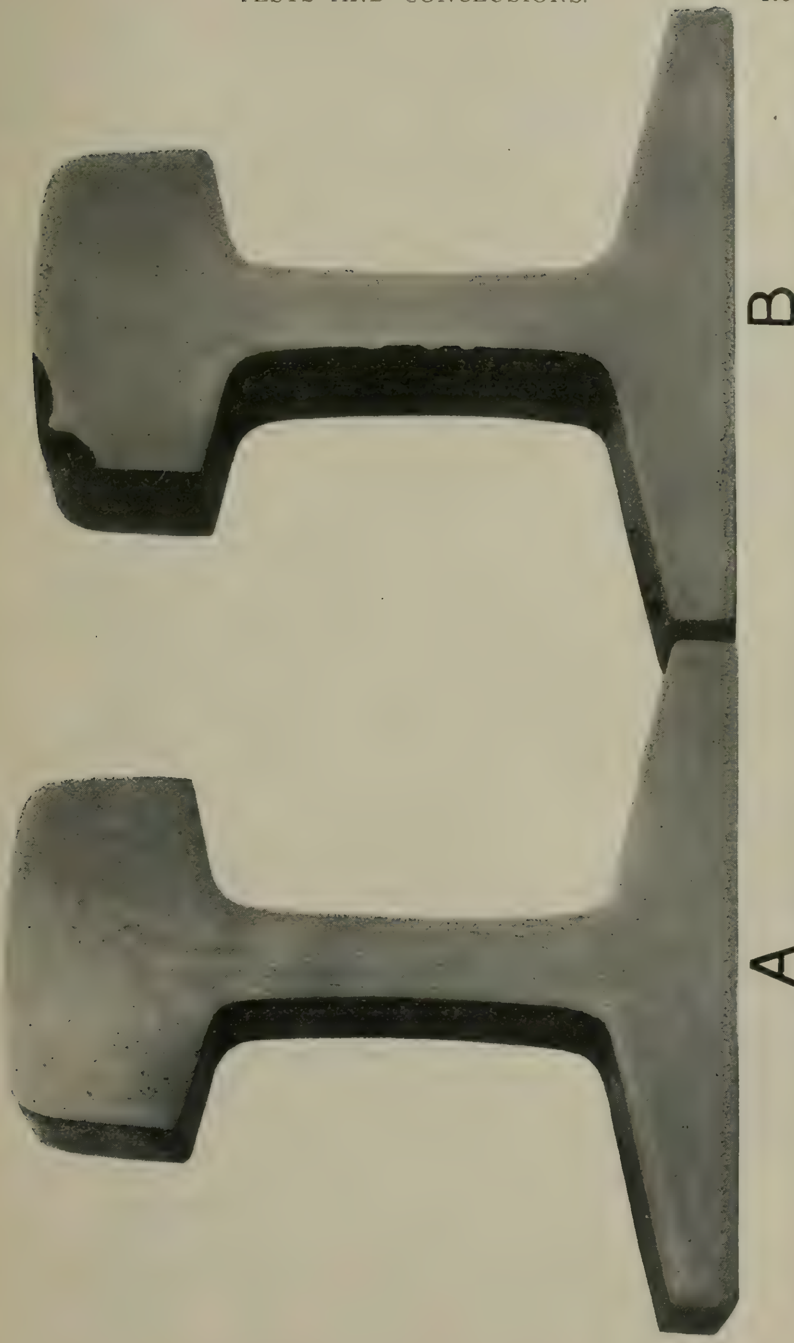


FIG. 2—TOP END OF A RAIL, ETCHED WITH HYDROCHLORIC ACID. FIG. 3—TOP END OF B RAIL, ETCHED WITH HYDROCHLORIC ACID.

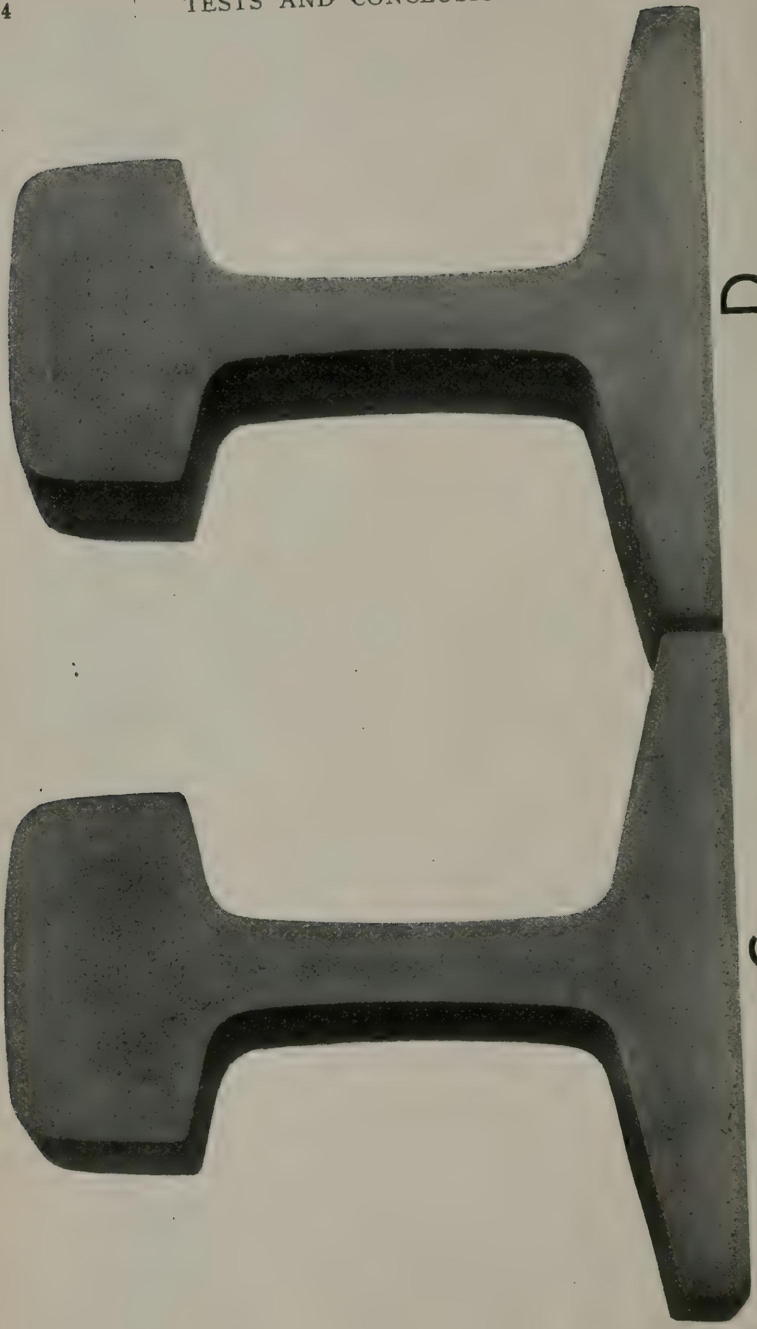


Fig. 4—Top End of C Rail, Etched with Hydrochloric Acid. Fig. 5—Top End of D Rail, Etched with Hydrochloric Acid.

TENSILE TESTS.

I had planned to make tensile tests of pieces from near the top end of each rail by cutting five flat pieces ⅜x1¼x16 inches from each rail as shown in Fig. 6. The test pieces were cut in this manner from the A and D rails, but it soon appeared that the time required to prepare the pieces in this manner would cause considerable delays, and then, too, the surfaces are apt to be finished in a condition unsatisfactory for test. I then changed the plan so as to obtain pieces ½ inch in diameter and 2-inch gauge length, as shown in Fig. 7. The pieces from the B and C rails were prepared in this manner. The results of the tensile tests are shown in the following table. Care must be taken not to compare the results of the flat test pieces with those from the round test pieces, except, perhaps, as regards the ten-

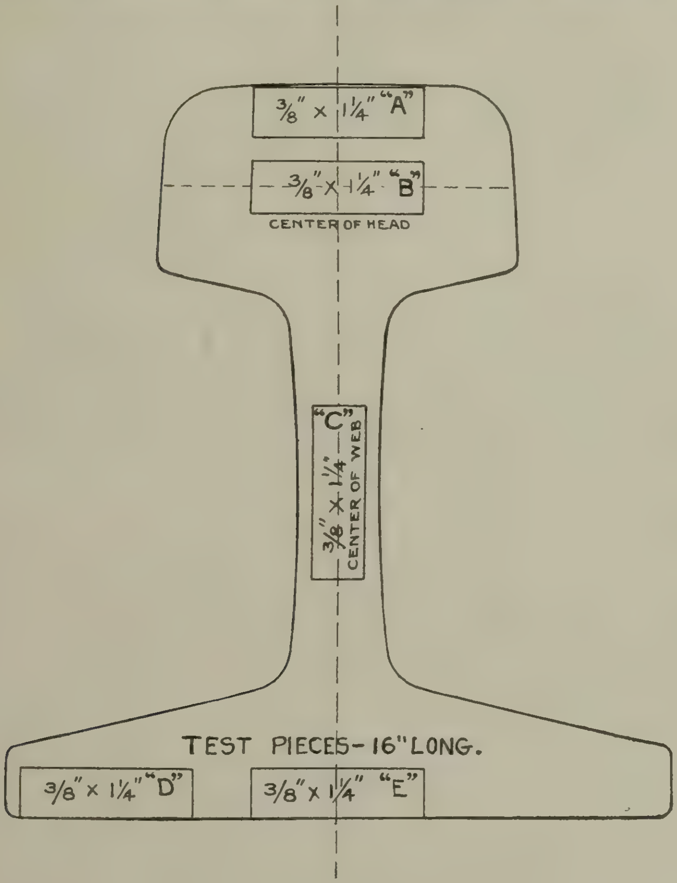


Fig. 6—Flat Tensile Test Pieces.

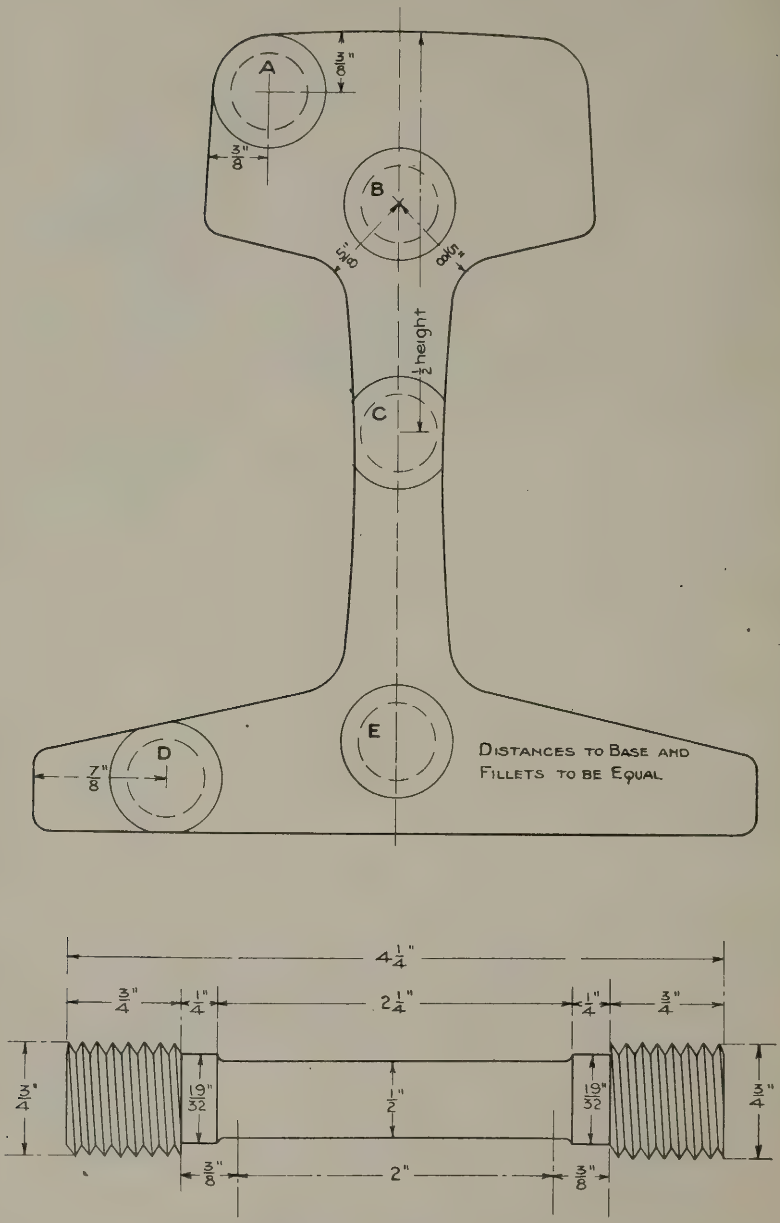


Fig. 7—Round Tensile Test Pieces.

sile strength, although even here the shape of the test piece would make some difference.

Rail.	Location.	Kind of Test Piece.	Tensile Str. per sq in.	Elongation.	Reduction of Area.
A	a Head	Flat	103,400	15.5 in 8″	23 flat
	b Head	“	111,100	20.0 in 8″	16 “
	c Web	“	109,200	14.5 in 8″	18 “
	d Flange	“	103,300	11.7 in 8″	19 “
	e Base	“	105,000	13.7 in 8″	21 “
B	a Head	Round	111,700	19.0 in 2″	29 round
	b Head	“	122,900	14.0 in 2″	20 “
	c Web	“	116,200	17.5 in 2″	27 “
	d Flange	“	110,700	19.0 in 2″	31 “
	e Base	“	111,600	18.0 in 2″	33 “
C	a Head	Round	109,100	20.0 in 2″	36 round
	b Head	“	112,100	16.0 in 2″	25 “
	c Web	“	112,300	21.0 in 2″	37 “
	d Flange	“	109,600	20.0 in 2″	34 “
	e Base	“	112,400	19.5 in 2″	33 “
D	a Head	Flat	109,800	12.5 in 8″	17 flat
	b Head	“	106,800	10.0 in 8″	12 “
	c Web	“	104,700	13.7 in 8″	23 “
	d Flange	“	108,600	10.0 in 8″	21 “
	e Base	“	110,000	9.5 in 8″	16 “

A study of these tensile tests will, I think, prove very interesting, and I group below the tensile strengths for convenience of comparison.

Location.	A Rail.	B Rail.	C Rail.	D Rail.
a Head	103,400	111,700	109,100	109,800
b Head	111,100	122,900	112,100	106,800
c Web	109,200	116,200	112,300	104,700
d Flange	103,300	110,700	109,600	108,600
e Base	105,000	111,600	112,400	110,000

In the A and B rails the b sample from the interior of the head and the c sample from the web, both of which represent what was originally the interior of the ingot, the tensile strength runs higher than in the other three locations, the highest increase being in the samples from the head. We have seen above that the analyses show that the interior is higher in the hardening elements in the case of the B rail, although not in the A rail. The five tensile samples from the C rail showed no large difference. The b and c samples from the D rail showed lower tensile strength than the other samples, and this again coincides with the findings of the chemical analyses, namely, that the interior of the D rail contains a lower amount of hardening elements and the C rail also showed a slight tendency the same way. A study of the elongation and reductions of area shows that the b sample from the interior of the head represents the place of lowest ductility in the section of the rail. The only exception was with the A rail, where the interior of the head showed highest elongation, but this result is so at variance with the others that it seems it must be in error. The web samples in general showed the greatest ductility. The a sample from the upper corner of the head and the d sample from the flange would be metal of about the same chemistry, but the finishing temperature of the flange is considerably lower than that of the head, and a comparison of these should be interesting as showing the influence of the difference of temperature. The results are compared below:

		A Rail.	B Rail.	C Rail.	D Rail.
Tensile strength,	a-head....	103,400	111,700	109,100	109,800
	b-flange...	103,300	110,700	109,600	108,600
Elongation,	a-head.....	15.5 fl.	19. rd.	20. rd.	12.5 fl.
	b-flange...	11.7 fl.	19. rd.	20. rd.	10.0 fl.
Reduction of area,	a-head....	23. fl.	29. rd.	36. rd.	17.0 fl.
	b-flange...	19. fl.	31. rd.	34. rd.	21.0 fl.

According to these results both the tensile strength and ductility are about the same in the upper corner of the head and in the flange, and the difference in finishing temperature seems not to have produced differences in the physical properties.

DROP TESTS.

Drop tests were made of pieces from near the top of the A, B, C and D rails of ingot L1 with heights of 18 feet, using the standard rail drop test machine with 2,000 lbs. tup, 3-foot supports and 5-inch radii and spring-supported anvil of 10 tons. Two pieces were tested from each rail, one with the head in tension and the other with the base in the tension. The results of the tests are shown in the following table:

Test No.	Head or Base in Tension.	No. of Blow.	Deflection.	1" Marks After Blow.					
				1	2	3	4	5	6
L1-A3	Head	1	....	1.08	1.09	1.09	1.07	1.05	1.04
		2	Broke	1.08	....	1.08	1.07	1.05	1.03
L1-A4	Base	1	1.85	1.06	1.07	1.08	1.08	1.06	1.05
		2	Broke	1.06	1.07	1.08	1.08	1.06	1.05
L1-B3	Head	1	1.88	1.02	1.04	1.06	1.06	1.09	1.08
		2	Broke	1.02	1.04	1.07	1.09	1.12	1.12

Test No.	Head or Base in Tension	No. of Blow.	Deflection.	1" Marks After Blow. 1	2	3	4	5	6
L1-B4	Base	1	1.85	1.07	1.07	1.06	1.06	1.05	1.03
		2	3.35	1.13	1.13	1.13	1.11	1.07	1.05
		3	4.82	1.21	1.20	1.16	1.12	1.08	1.05
		4	Broke	1.21	1.20	....	1.12	1.08	1.06
L1-C3	Head	1	Broke	1.03	1.05	1.06	1.09	....	1.06
L1-C4	Base	1	1.89	1.03	1.05	1.06	1.07	1.07	1.04
		2	3.42	1.06	1.10	1.10	1.14	1.14	1.11
		3	4.96	1.08	1.13	1.17	1.19	1.20	1.14
		4	Broke	1.09	....	1.18	1.21	1.22	....
L1-D3	Head	1	1.96	1.06	1.06	1.09	1.09	1.09	1.04
		2	3.63	1.08	1.11	1.17	1.20	1.19	1.10
		3	5.38	1.12	1.17	1.26	1.30	1.28	1.14
		4	Broke	1.14	1.19	1.27	1.31	1.29	1.16
L1-D4	Base	1	1.93	1.04	1.05	1.06	1.06	1.06	1.05
		2	Broke	1.05	1.10	1.14	....	1.13	1.10

The rails were all broken with blows varying from one to four, and I give below a table showing the elongation obtained after the first blow and also the deflection after the first blow, the head or the base being in tension as noted.

	Elongation First Blow, Head.	Base.	Deflection First Blow, Head.	Base.
L1-A	9%	8%	...	1.85
LI-B	9%	7%	1.88	1.85
L1-C	9%	7%	...	1.89
L1-D	9%	6%	1.96	1.93

It will be noted that the lower rails of the ingot gave a little more deflection under the drop indicating that the upper rails were slightly stiffer. This again agrees with the indications of the analyses and tensile tests.

The deflection is about the same with the head or base in tension, but the elongation is greater with the head in tension.

I give below a table showing the maximum elongation when broken:

	Head in Tension, Blows.	Elongation.	Base in Tension, Blows.	Elongation.
L1-A	2	9%	2	8%
L1-B	2	12%	4	21%
L1-C	1	9%	4	22%
L1-D	4	31%	2	14%

BENDING TESTS.

Two pieces 4½ feet long were cut from each rail for bending in the test machine, one piece being bent with the head in tension and the other with the base in tension, using a span of three feet. The supports were triangular blocks with edges rounded somewhat. The loading block had a five-inch radius. The deflections were determined by measuring the distance between the lower side of the rail and a block on the weighing platform of the test machine, which of course included the spring of the supports and also the distortion of the rail in fitting itself to the

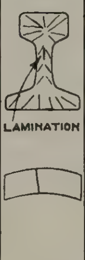
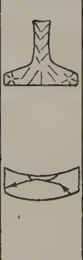
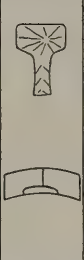
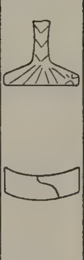
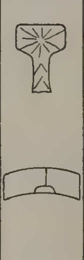
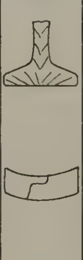
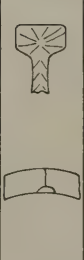
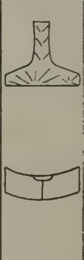
	L1A		L1B		L1C		L1D	
HEAD OR BASE IN TENSION	HEAD	BASE	HEAD	BASE	HEAD	BASE	HEAD	BASE
LOAD	DEFL.	DEFL.	DEFL.	DEFL.	DEFL.	DEFL.	DEFL.	DEFL.
20,000	.059	.048	.037	.074	.079	.062	.065	.062
40,000	.098	.082	.078	.106	.115	.102	.102	.098
60,000	.130	115	.116	.136	.150	.135	.133	.133
80,000	.165	.145	.153	.166	.185	.173	.165	.165
90,000	.183	.163	.173	.183	.206	.192	.185	.182
100,000	.208	.184	.196	.202	.224	.212	.203	.202
110,000	.245	.209	.227	.222	.255	.238	.228	.224
120,000	.333	.277	.323	.264	.340	.295	.323	.285
130,000	.460	.405	.440	.374	.450	.420	.450	.420
140,000	.580	.535	.60	.51	.59	.56	.59	.58
150,000	.780	.760	.78	.69	.77	.72	.77	.72
160,000	1.00	.96	1.02	.85	.95	.92	.99	.94
170,000		1.18	1.32	1.13	1.23	1.18	1.29	1.16
180,000		1.48	1.68	1.37	1.63	1.42	1.63	1.48
190,000			2.20	1.67	2.03	1.78	2.15	1.84
200,000				2.13		2.20		2.30
210,000		2.96		2.61		2.84		3.16
BROKE	167,800#	212,900#	196,000#	218,300#	198,900#	219,700#	196,300#	214,600#
ELONGATION 1" MARKS 1	1.04	1.08	1.08	1.11	1.07	1.15	1.09	1.12
2	1.04	1.10	1.13	1.18	1.10	1.18	1.15	1.15
3	1.06	1.12		1.19		1.23	1.20	1.18
4	1.04		1.17	1.19	1.14	1.20	1.20	1.25
5	1.04	1.10	1.12	1.17	1.11	1.16	1.15	1.16
6	1.02	1,06	1.08	1.11	1.07	1.10	1.09	1.11
								

FIG. 8—BENDING TESTS IN TEST MACHINE.

supports under the application of the load. This measurement, however, allows the elastic limit to be determined approximately, which is the important thing to be determined by this test, but of course it would not be available for calculation of the modulus of elasticity. The elongation of the metal when broken was determined by putting gage marks one inch apart over a distance of six inches at the middle of the rail on the side in tension. The highest stretch obtained in any one inch is taken as the maximum elongation obtained. The results of the bending tests are shown in Fig. 8 and the plotted load-deflection diagrams of the four rails are shown in Fig. 9. The breaking loads and the maximum elongations obtained are given below for convenience of comparison:

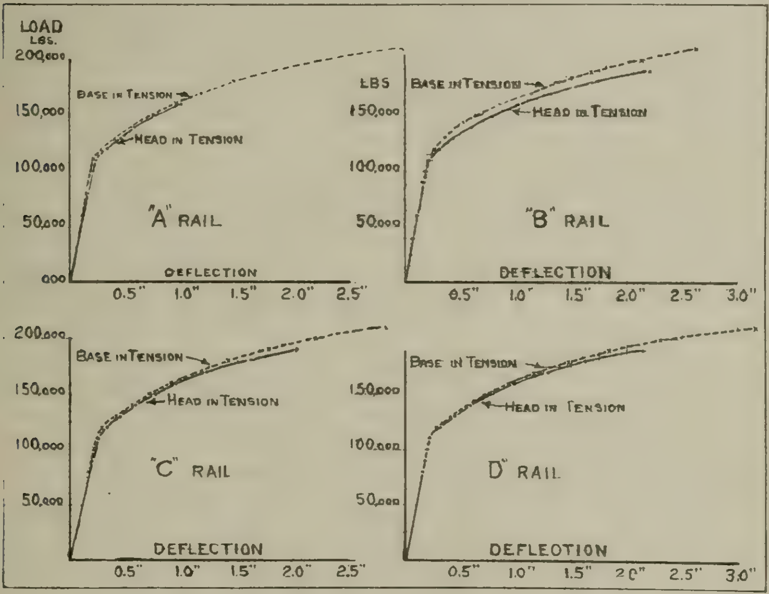


FIG. 9—LOAD DEFLECTION DIAGRAMS.

	Breaking Load,		Maximum Elongation,	
Rail.	Head in Tension.	Base in Tension.	Head in Tension.	Base in Tension.
A..............	167,800	212,900	6%	12%
B..............	196,000	218,300	17%	19%
C..............	198,000	219,700	14%	23%
D..............	196,300	214,600	20%	25%

It will be noted that these rails stood more load before breaking with the base in tension than with the head in tension, and also stood greater elongations with the base in tension. The "A" rail with the head in tension broke at a considerably less load than the other rails. It is interesting to note that the rails give increasing elongations as we proceed down the ingot, the only exception being the "C" rail, with head in tension, which gave low elongation. This same rail tested in the drop machine acted in a similar manner, the part struck in the drop test having been a rail distance of 9 feet higher up the ingot than the part bent in the test machine. The comparison of the elongations in slow bending and in the drop test is shown in the following table:

	Head in Tension,		Base in Tension,	
	Drop.	Slow Bending.	Drop.	Slow Bending.
A	9%	6%	8%	12%
B	12%	17%	21%	19%
C	9%	14%	22%	23%
D	31%	20%	14%	25%

The elongations are rather irregular, but it will be noted that sometimes the elongation was greater in the drop test and sometimes greater in the slow bending test. The averages of all the results were 15¾% for the drop tests and 17% for the slow bending tests, which suggests that the metal behaves about the same in the two tests.

The elastic limit in bending with supports three feet apart is shown by the deflection diagrams to be about 110,000 lbs. for all the rails. There are probably slight differences between the different rails, but the method of measurement would have to be more refined to detect them with certainty. The rails seem to have the elastic limit about 2,000 lbs. higher with the base in tension than with the head in tension.

Finally, I wish to acknowledge the courteous treatment I received from the officers of the Lackawanna Steel Company and their kindness in freely offering the facilities of their plant for the tests discussed above. The thanks of the committee are also due to Mr. A. S. Baldwin for making most of the tracings.

TESTS OF BESSEMER RAILS—ILLINOIS STEEL CO., SOUTH WORKS.

By M. H. Wickhorst, Engineer of Tests, Rail Committee.

This report covers tests of some 100-lb. Bessemer rails, A. R. A. type B, made at the South Chicago Works of the Illinois Steel Company, May 7, 1910, Illinois Steel Company section 10030.

MANUFACTURE.

The test rails were from three ingots of heat 24,888. Lake Superior ore was used reduced partly in ordinary blast furnaces and partly in furnaces using dry blast, that is, air which had been cooled to reduce its moisture content. The metal from the blast furnaces was poured into a 300-ton mixer from which it was weighed and poured into the converter. Scrap was also added to the converter and after blowing, spiegel was added to the converter, the metal was poured into an intermediate ladle, then into the teeming ladle and finally into the molds through a 1½-inch nozzle. The amounts used were as follows:

Mixer metal	27,100 lbs.
Scrap	4,000 lbs.
Spiegel	3,300 lbs.

Samples of the mixer metal and spiegel gave the following results on analysis:

	Carb.	Phos.	Sulph.	Mang.	Sil.
Mixer metal	4.14	.095	.036	.74	1.71
Spiegel	4.32	.094	.014	11.38	2.38

The heat made eight ingots, each ingot making three rails. Clay wash was used on the stools of the molds, and the molds were sprayed with a little coal tar. The ingot molds were 18x19½ inches at the bottom and

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Report No. 4, June, 1910.

16x17½ inches at the top. The test ingots were the third, fourth and fifth of the pouring, with an average weight of 3,975 lbs., the sample for the heat analysis being taken while pouring the fifth ingot. These ingots were given test numbers Il-1, Il-2, and Il-3, the three rails from ingot Il-1 being used for our various special tests and the other rails being held for service tests. The ingots were bloomed to 8x8 inches in nine passes and finished in nine passes, making a total of 18 passes from ingot to finished rail. The reduction of area was from 322.6 sq. in. to 10.1 sq. in., or a reduction of 32 times. The areas of the various passes as furnished by the Steel Company of their section 10030, which is the A. R. A. type B, 100-lb. rail, are as follows:

Pass No.	Operation.	Area.	Pass No.	Operation.	Area.
	Ingot	322.6	10	1st rougher	49.6
1	Blooming	293.1	11	“ “	33.3
2	“	261.7	12	“ “	25.3
3	“	215.5	13	2d rougher	19.7
4	“	185.8	14	dummy	18.8
5	“	148.5	15	finishing	15.2
6	“	119.8	16	“	12.4
7	“	97.5	17	“	10.5
8	“	77.5	18	“	10.1
9	“	65.2			

The discards were as follows:

	Il-1.	Il-2.	Il-3.
Top of bloom	9.0%	10.7%	9.6%
Top of rail bar	1.5%	1.5%	1.7%
Total from top of ingot	10.5%	12.2%	11.3%
Bottom of bloom	3.6%	4.3%	2.8%
Bottom of rail bar	2.2%	1.8%	2.2%
Total from bottom of ingot	5.8%	6.1%	5.0%
Total from ingot	16.3%	18.3%	16.3%

The cambers of the rails before straightening were as follows:

No.	Camber.	Concave Head or Base Side.
Il-1 A	⅝-in.	Base
B	1	Head
C	1½	Head
Il-2 A	⅞-in.	Base
B	⅝-in.	Head
C	1¾-in.	Head
Il-3 A	1⅛-in.	Base
B	1 1/16-in.	Head
C	2	Head

Pieces were cut from each rail of ingot Il-1 for tests as listed below:
18 inches—Chemical analysis, etching and tensile tests.
4½ ft.—Drop test—head in tension.
4½ ft.—Drop test—base in tension.
4½ ft.—Bending test—head in tension.
4½ ft.—Bending test—base in tension.

CHEMICAL ANALYSES.

Analyses were made of two samples from near the top of each rail, as shown in Fig. 1, one sample from the upper corner of the head to

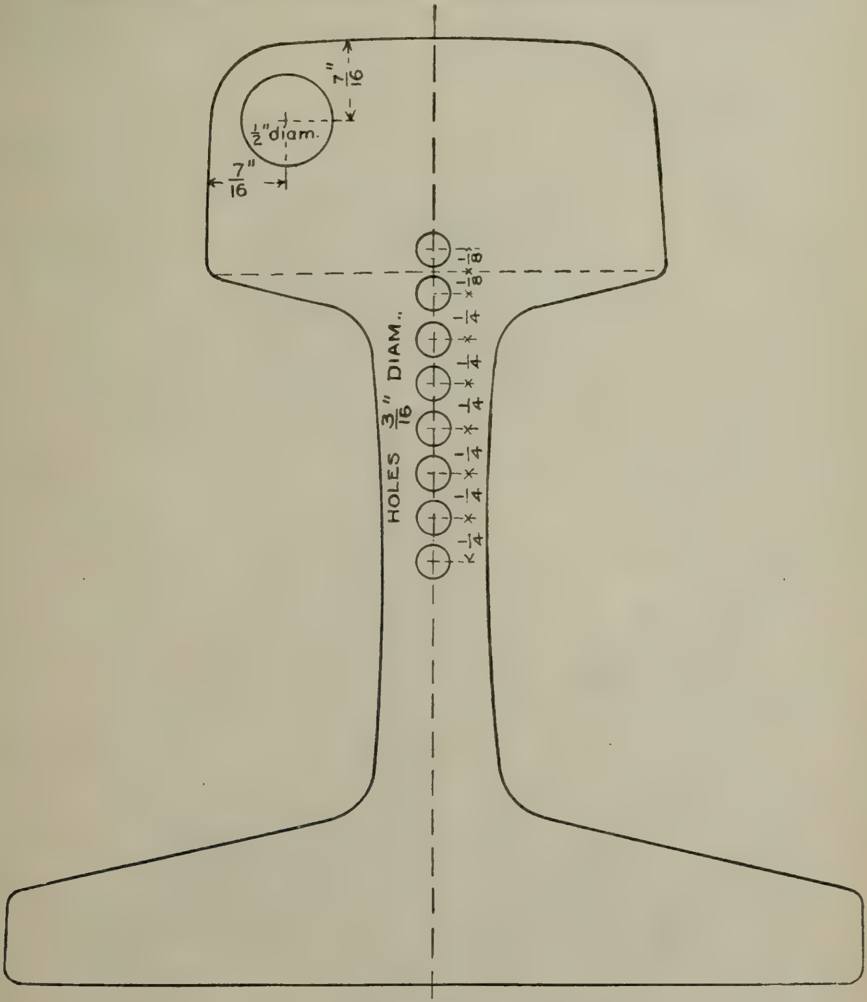


FIG. 1—SAMPLES FOR ANALYSIS.

represent the normal metal and the other sample from the web to represent the segregated metal if present. These analyses and the heat analysis are given in the following table:

Rail.	Location.	Carbon.	Phos.	Sulph.	Mang.	Sil.
A	Head	.51	.094	.036	1.04	.146
	Web	.59	.115	.047	1.07	.154
B	Head	.53	.100	.038	1.03	.146
	Web	.54	.102	.040	1.04	.149
C	Head	.49	1.00	.039	1.04	.144
	Web	.53	.091	.037	1.02	.146
Heat analysis		.50	.098	.038	1.00	.157

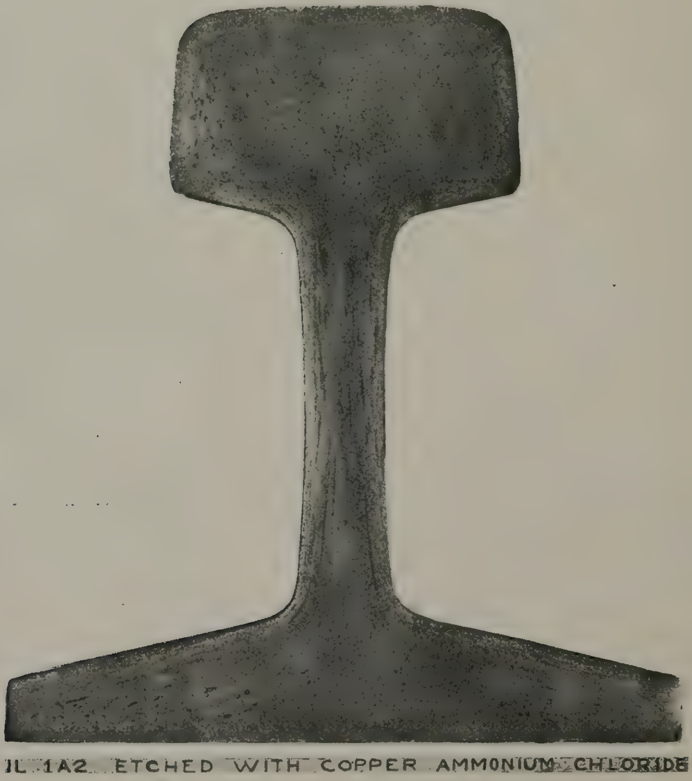


Fig. 2—Top End of A Rail.

It will be noted that the web of the "A" rail shows a little segregation of the carbon, phosphorus and sulphur, as indicated below:

	Carbon.	Phos.	Sulph.
Head	.51	.094	.036
Web	.59	.115	.047
Increase	18%	22%	31%

The B and C rails show about the same chemistry in the head and web. The manganese and silicon show but little segregation. The rails contained no other element besides iron and the ones given above.

ETCHING.

Sections were cut from near the top of each rail, polished and etched with a solution of copper ammonium chloride. Photographs of the etched surfaces are reproduced in Figs. 2, 3 and 4. The A rail shows a great

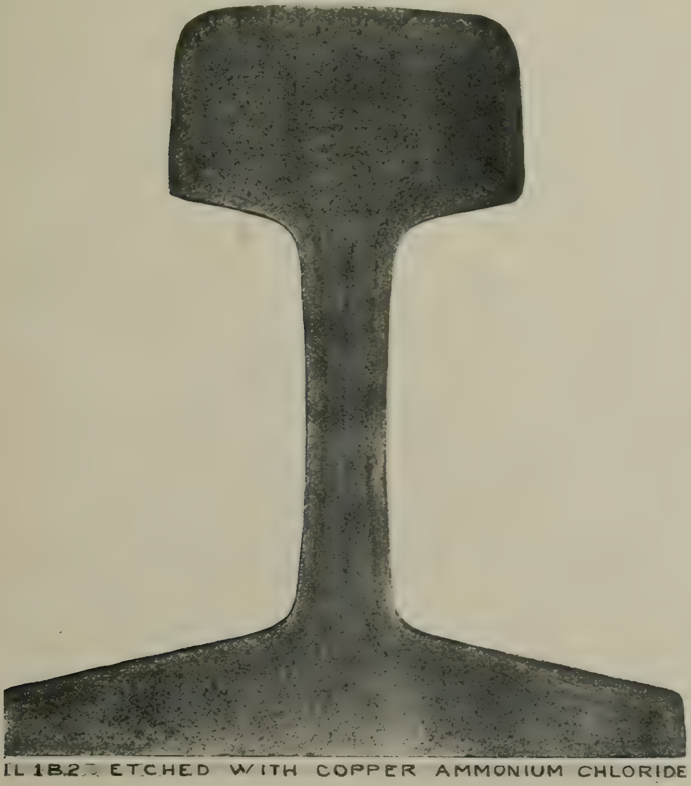


FIG. 3—TOP END OF B RAIL.

many spots and streaks which probably show points of segregation of carbon, phosphorus and sulphur, although some may perhaps be due to laminations and slag. The B and C rails show only a few such spots and streaks.

TENSILE TESTS.

Tensile tests were made of pieces cut from near the top end of each rail, as shown in Fig. 5. It was intended to have all the pieces one-half-inch diameter with a gauge length of two inches, but through misunderstanding the pieces from the head and base were made 9-16-inch diameter and those from the web and flange were made 7-16-inch diameter. The results of the tensile tests are shown in the following table. Each bar for the test pieces was cut sufficiently long to make two test pieces, both of which were pulled. Both results are given in the table:

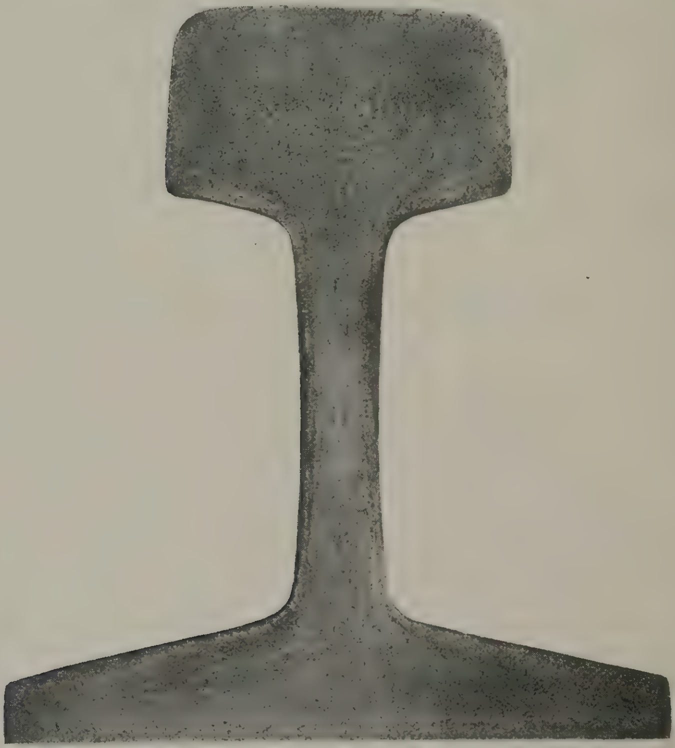


Fig. 4—Top End of C Rail.

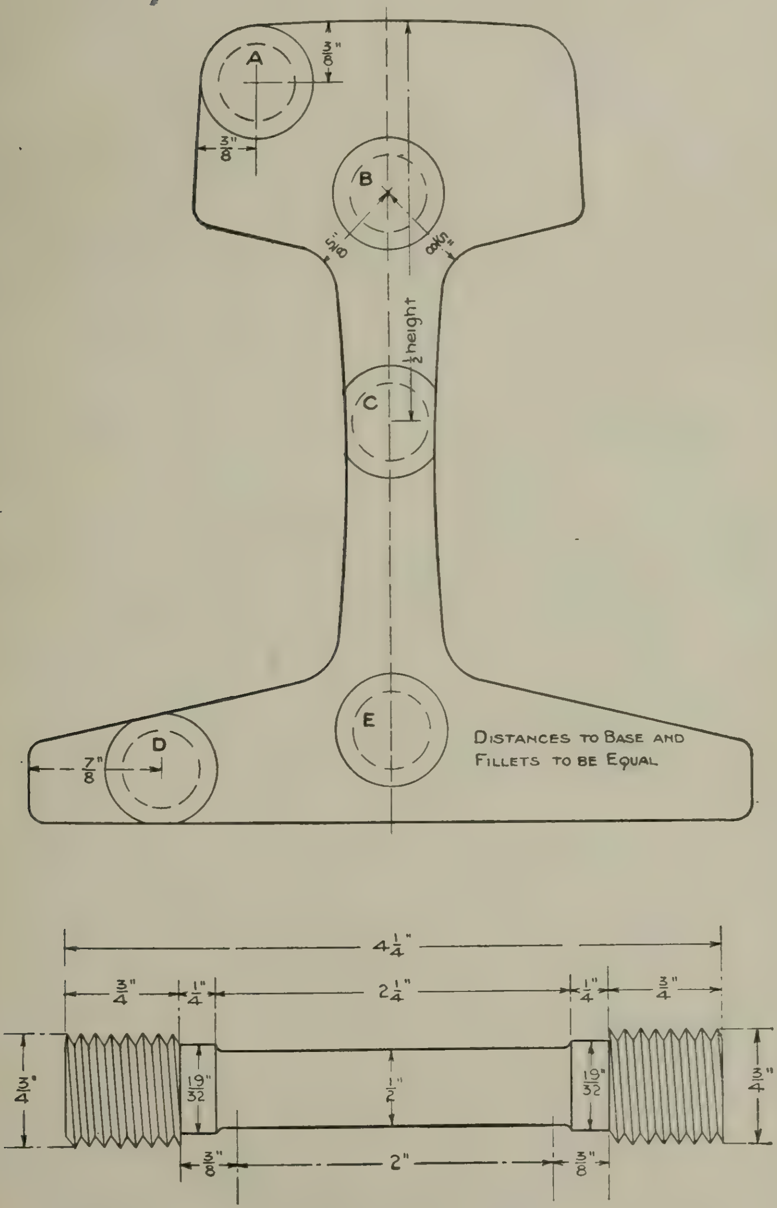


Fig. 5—Tensile Test Pieces.

Rail.	Location.	Tens. Str. per sq. in.	Elongation in 2 in.	Reduction of Area
A	a, head, corner	107,600	4%	5%
		114,500	6%	5%
	b, head, interior	112,500	2%	0%
		128,150	7%	5%
	c, web	131,600	11%	20%
		130,500	8%	11%
	d, flange	124,700	10%	18%
		123,400	10%	15%
	e, base	123,000	13%	26%
		119,400	5%	2%
B	a, head, corner	120,600	17%	31%
		121,800	17%	29%
	b, head, interior	123,800	6%	4%
		125,900	9%	9%
	c, web	128,500	11%	23%
		125,300	13%	28%
	d, flange	124,700	16%	32%
		125,300	14%	33%
	e, base	125,000	15%	27%
		124,600	13%	27%
C	a, head, corner	123,000	16%	30%
		122,200	16%	30%
	b, head, interior	118,900	15%	25%
		118,900	12%	16%
	c, web	120,700	13%	30%
		122,100	14%	31%
	d, flange	126,500	14%	32%
		126,000	14%	33%
	e, base	123,000	14%	23%
		124,200	15%	23%

One noticeable feature of the above results is the low ductility shown by a large part of the samples from the A rail, especially by the samples from the head. In all the rails the b samples from the interior of the head showed the lowest ductility. A comparison of the tensile strength also is interesting, and I give below a table showing the tensile results. Each test was made in duplicate and in the table I give the tensile strength of the sample which showed the greatest ductility, that is, the highest elongation and reduction of area. When the material breaks brittle with low stretch, its full strength is apt not to be developed, and this was evidently the case with several of the pieces from the A rail. The duplicates from the A rail show some large differences, but in the B and C rails the duplicates agree well with each other, which suggests considerable internal irregularities in the A rail. In the table below I have omitted the tensile strength of the a sample from the upper corner of the head of the A rail, as both duplicates broke "short."

Location,	A Rail.	B Rail.	C Rail.
a, head	......	120,600	123,000
b, head	128,150	125,900	118,900
c, web	131,600	125,300	122,100
d, flange	124,700	124,700	126,000
e, base	123,000	125,000	124,200

The b sample from the interior of the head and the c sample from the web represent what was originally the interior of the ingot, and it will be noticed that in the A rail these samples showed higher strengths than the other samples of the section. In the B rail these samples showed results a little higher, while in the C rail the b and c samples showed a lower tensile strength. The analyses showed a larger amount of the hardening elements in the interior of the A rail.

The a sample from the upper corner of the head and the d sample from the flange would be metal of about the same chemistry, but the flange has a finishing temperature considerably lower than the head and the metal is also reduced differently, and I give below a table showing the results from these two places:

	Location.	A Rail.	B Rail.	C Rail.
Tensile strength,	a, head	114,500	120,600	123,000
	d, flange	124,700	124,700	126,000
Elongation in 2 in.	a, head	6%	17%	16%
	d, flange	10%	16%	14%
Reduction of area	a, head	5%	31%	30%
	d, flange	18%	32%	33%

The a sample from the head of the A rail, having low ductility, evidently broke "short" and gave a low tensile strength, and its results should be neglected in this comparison. In the B and C rails the flange samples show somewhat higher tensile strength than the head samples, but show about the same ductility. The difference in finishing temperature seems therefore to have produced small, if any, difference in the tensile properties.

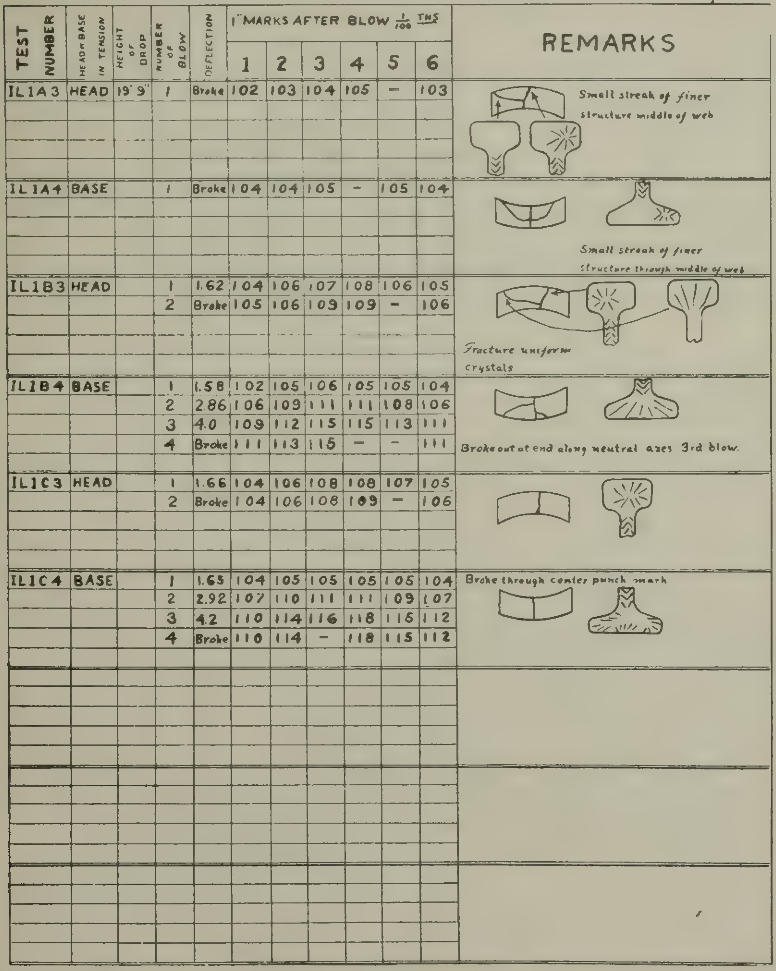
The b sample from the interior of the head and the c sample from the web would be of similar chemistry as representing the interior of the ingot, but the web is thinner and probably gets more work in rolling and probably is finished at a lower temperature. A comparison of these two locations is shown below:

	Location.	A Rail.	B Rail.	C Rail.
Tensile strength	b, head	128,150	125,900	118,900
	c, web	131,600	125,300	122,100
Elongation in 2 in.	b, head	7%	9%	15%
	c, web	11%	13%	14%
Reduction of area	b, head	5%	9%	25%
	c, web	20%	28%	31%

In the A rail the web shows a little higher tensile strength and very much greater ductility than the interior of the head. In the B rail the strength is about the same in the two locations, but the ductility is very much greater in the web, although the difference is not quite so great as in the A rail. In the C rail the strength is a little greater in the web than in the interior of the head, but the ductility is about the same. The web increases somewhat in ductility as we go down the ingot from the A to the C rail, but the increase in ductility of the interior of the head is very striking. We have already seen that the tensile strength of the interior metal decreases as we go down the ingot, the total decrease being almost 10,000 lbs. per sq. in., and this decrease in strength is almost sufficient to account for the increase in ductility in the web. A decrease in strength of 10,000 lbs. per sq. in. should increase the elongation about 3% and the reduction of area about 4% or 5%, while the actual increases were 3% and 11%, respectively. The increase of elongation in the interior of the head was 8% and the increase of reduction was 20%. A study of these differences in connection with the etchings I think proves very interesting, and perhaps offers a suggestion of the reason for the difference. The etching of the A rail shows a great many spots and streaks, most of which are probably centers of segregation of carbon, phosphorus and sulphur, although some of them may represent laminations and slag streaks. In the head these spots retain the rounded shape which they probably have in the ingot, while in the web they are flattened, showing that they are stretched in the web vertically as well as longitudinally, and they must, it would seem, be broken up more effectively than in the head. The B and C rails contain only a few of these spots and streaks. In the A rail the interior of the web shows good ductility, due, as suggested by the above observations, to the segregation spots being worked effectively, while in the interior of the head the work seems not to have been sufficient to impart much ductility. The C rail shows good ductility in the interior of both the head and the web, according to this explanation, because this rail contains few or no segregation spots to be broken down. The b and c samples of the B rail have properties between those of the A and C rails.

DROP TESTS.

Two drop tests were made of each of the three rails, one with the head in tension and the other with the base in tension, and the results are



TEST NUMBER	HEAD or BASE IN TENSION	HEIGHT OF DROP	NUMBER OF BLOW	DEFLECTION	1" MARKS AFTER BLOW $\frac{1}{100}$ THS						REMARKS
					1	2	3	4	5	6	
IL1A3	HEAD	19' 9"	1	Broke	102	103	104	105	–	103	Small streak of finer structure middle of web
IL1A4	BASE		1	Broke	104	104	105	–	105	104	Small streak of finer structure through middle of web
IL1B3	HEAD		1	1.62	104	106	107	108	106	105	Fracture uniform crystals
			2	Broke	105	106	109	109	–	106	
IL1B4	BASE		1	1.58	102	105	106	105	105	104	Broke out at end along neutral axes 3rd blow.
			2	2.86	106	109	111	111	108	106	
			3	4.0	109	112	115	115	113	111	
			4	Broke	111	113	115	–	–	111	
IL1C3	HEAD		1	1.66	104	106	108	108	107	105	
			2	Broke	104	106	108	109	–	106	
IL1C4	BASE		1	1.65	104	105	105	105	105	104	Broke through center punch mark
			2	2.92	107	110	111	111	109	107	
			3	4.2	110	114	116	118	115	112	
			4	Broke	110	114	–	118	115	112	

FIG. 6—DROP TESTS.

given in Fig. 6, which shows the deflections, elongations and diagrams of the fractures. The tup was 2,030 lbs. and the height was 19 ft. 9 in., which is about equivalent to a tup of 2,000 lbs. at a height of 20 ft. The standard spring-supported anvil of 10 tons was used, with supports three feet apart. The results showing deflection after the first blow and the elongation are compared in the following table:

	Elongation—1st Blow.		Deflection—1st Blow.	
Rail.	Head-Ten.	Base-Ten.	Head-Ten.	Base-Ten.
A................	5% broke	5% broke	.....	.....
B................	8%	6%	1.62"	1.58"
C................	8%	5%	1.66"	1.65"

The deflection is about the same with either the head or base in tension, but the head elongates about 50% more than the base for the same deflection of the rail. The B rail also seems to be a trifle stiffer than the C rail.

The number of blows which broke the rails and the maximum elongations obtained were as follows:

	Maximum Elongation.		No. of Blows.	
Rail.	Head-Ten.	Base-Ten.	Head-Ten.	Base-Ten.
A................	5%	5%	1	1
B................	9%	15%	2	4
C................	9%	18%	2	4

The A rail, it will be noted, did not stand one blow with either head or base in tension. Figuring from the elongations, the A rail with the head in tension would have just broken with a drop of about 12½ ft. and with the base in tension of about 18 ft. With the head in tension, both the B and C rails gave almost their maximum deflection under the first blow, as shown by the elongations. Failure occurred at 9% elongation, while the first blow gave 8% elongation. With the base in tension, the B and C rails stood the first blow very easily.

The three fractures with head in tension showed fracture lines radiating from a point within the head, indicating the point where the breaks started. The fracture of the C rail with head in tension showed these fracture lines radiating from near the center of the head very nicely, and a photograph of this fracture is reproduced as Fig. 7 and shown as test II-1 C3.

BENDING TESTS.

Two pieces 4½ ft. long were cut from each rail for bending in the test machine, one being bent with the head in tension and the other with the base in tension, using a span of three feet. The supports were flat surfaces whose edges were three feet apart. I had desired to bend the rails to destruction, but was permitted by the steel company to put on only sufficient load to give the rails a permanent set, as the pieces fly badly when the rail breaks. Although suitable guards can be put up, it was preferred not to take the possible chance of damage to the test machine. The deflections were determined by measuring the distance between the under side of the rail and a block on the weighing platform of the test machine, using a deflectometer reading to .001 inch. This method is not entirely satisfactory, as the deflection so obtained includes the drop of the rail adjusting itself to the supports and the compression of the supports, etc., but it allows an approximate determination of the elastic limit. The deflections obtained are shown in the following table, the heading "Head" or "Base" referring to the part in tension:

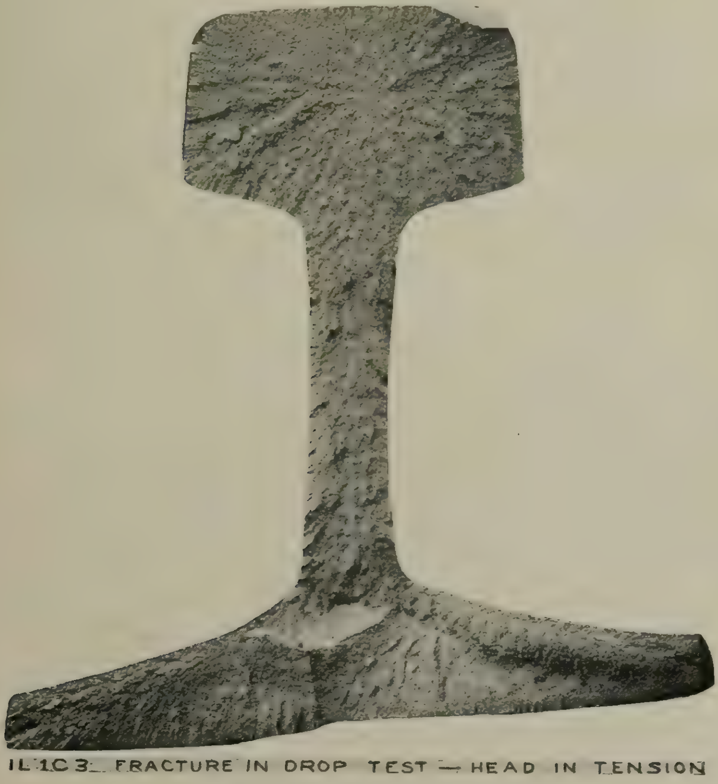


FIG. 7—FRACTURE SHOWING "STAR" IN HEAD, INDICATING INITIAL POINT OF BREAK.

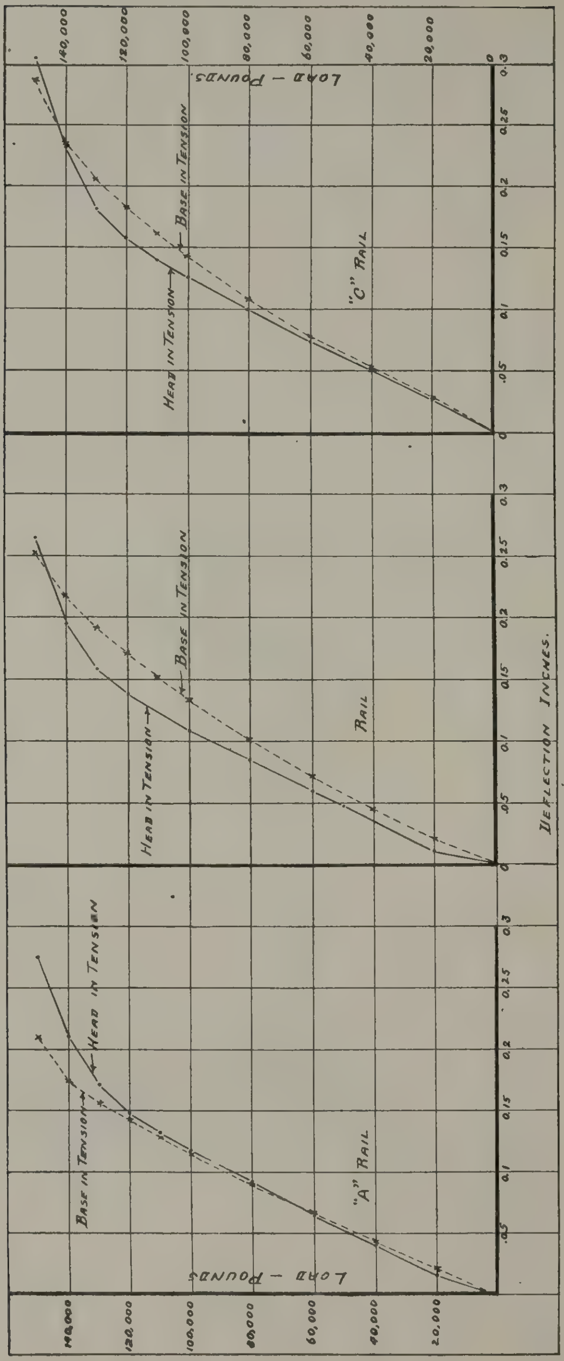


FIG 8—LOAD-DEFLECTION DIAGRAMS.

	Il-1 A.		Il-1 B.		Il-1 C.	
	Head.	Base.	Head.	Base.	Head.	Base.
20,000 lbs.	.017″	.021″	.012″	.021″	.026″	.029″
40,000 "	.042″	.044″	.....	.045″	.051″	.053″
60,000 "	.066″	.067″	.060″	.072″	.075″	.079″
80,000 "	.092″	.090″	.085″	.102″	.100″	.109″
100,000 "	.118″	.115″	.109″	.132″	.127″	.144″
110,000 "	.132″	.128″	.123″	.152″	.141″	.162″
120,000 "	.149″	.143″	.138″	.171″	.158″	.183″
130,000 "	.172″	.156″	.159″	.192″	.182″	.206″
140,000 "	.211″	.174″	.197″	.217″	.232″	.234″
150,000 "	.275″	.210″	.265″	.253″	.306″	.288″

The above results are plotted in Fig. 8, showing the load-deflection diagrams, which show the elastic limit of these rails with three feet span to be about 120,000 lbs. with the head in tension and about 130,000 lbs. with the base in tension.

Finally, I wish to acknowledge the courtesies extended to me by the steel company in offering the use of their facilities for making the tests described above, and the considerable help I obtained from their efficient testing organization.

REPORT OF TESTS OF OPEN-HEARTH RAILS—GARY WORKS, 100 LB. A. R. A. TYPE B,

By M. H. WICKHORST, Engineer of Tests, Rail Committee.

This report covers tests of some 100-lb. open-hearth rail, A. R. A. type B, made at the Gary Works (Ind.) of the Illinois Steel Co., May 11, 1910, Gary section 10030.

MANUFACTURE.

The test rails were from three ingots of heat 55178. Lake Superior ore was used, reduced in blast furnaces using ordinary air and having the following average charge:

Coke	12,000 lbs.
Stone	5,100 lbs.
Ore	26,500 lbs.

A mixture of ores was used, but consisted largely of Chapin ore showing analysis as follows:

	Per cent.
Iron	54.63
Aluminum (about)	2.00
Manganese	.21
Phosphorus	.059
Sulphur	trace
Silica (SiO_2)	5.51

The limestone used analyzed about as follows:

	Per cent.
Calcium oxide	54.67
Magnesium oxide	.53
Iron and aluminum oxides	.74
Silica	.68

The iron from the blast furnaces was poured into a mixer, from which it was weighed.

The process of steel production consisted of charging limestone

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and ore into a basic open-hearth furnace heated with producer gas and piling on scrap. The charging was started at 7:29 a. m. After 2¾ hours liquid mixer metal was added, and the whole was melted down until the tapping test showed carbon .26 per cent. by fracture. During the melting, small quantities of fluor-spar were added at intervals to make the slag more fluid and assist in the melting. The additions of fluor-spar started at 2:50 p. m. and amounted to about 1,300 lbs. total. At 3:00 p. m. a furnace sample was taken and the phosphorus found to be .012 per cent. At 4:25 p. m. 150 lbs. of ore was added. Mixer metal to recarbonize was added to the furnace at 5:02 p. m. The furnace was tapped at 5:12 p. m. and ferromanganese (80 per cent.) and ferrosilicon (50 per cent.) were added to the ladle, shortly after tapping.

The amounts of the various materials used were as follows:

	Pounds.
Limestone	25,000
Ore (Chapin)	15,000
Scrap steel	60,400
Mixer metal, 1st charge	110,900
Mixer metal, to recarbonize	24,000
Ferromanganese	1,000
Ferrosilicon	500

A sample of the mixer metal used to charge the furnace gave the following analysis:

	Per cent.
Carbon	3.85
Silicon	1.73
Manganese	1.50
Phosphorus	.215
Sulphur	.030

(I was told that the silicon in the mixer metal ordinarily averaged about 1.25 per cent. instead of 1.73, as shown above.)

The ferromanganese and ferrosilicon had compositions about as follows:

	Ferromanganese. Per cent.	Ferrosilicon. Per cent.
Manganese	80.0	.3
Silicon	1.0	54.0
Carbon	6.5	.3
Phosphorus	.3	.02
Sulphur	.04	.02

The heat made 21 ingots with an average weight of 8,073 lbs. and each ingot made six rails. The stools were washed with clay wash, but the molds were not coated. The ingot molds were 20x24 in. at the bottom, with a taper of ¼-in. per foot, making a 72-in. ingot 18½x22½ in. at the top. The metal was poured through a 2-in. nozzle and the pouring of the 21 ingots took from 5:30 p. m. to 5:56 p. m., or 26 min. The ingots selected for the test rails were the eighth, ninth and tenth of the pouring, and the sample for ladle analysis was taken while pouring the tenth ingot. These ingots were given test numbers, G1, G2 and G3, respectively. The six rails from ingot G1 were used for our various special tests and the rails of the other two ingots are being held at Gary, to be later used for service test. It should be stated here that there was a "running stopper" during the pouring of this heat, that is, the flow of metal could not be shut off while transferring the ladle from mold to mold, which occurrence is apt to cause scabby ingots, due to metal splashing on the sides of the molds. The ingots for test rails were in the soaking pit from 7:04 p. m. to 9:13 p. m., or 2 hrs. 9 min.

The ingots were bloomed to 8x8 in. in 9 passes and finished in 9 passes, making a total of 18 passes from ingot to rail. The reduction of the rail was from 400 sq. in. at the top of the ingot to 10.1 sq. in., or a reduction of 39 times. The areas of the various passes, as furnished by the Steel Company at Gary, of their section 10030, which is the A. R. A. type B 100-lb. rail, are as follows:

Pass No.	Area Sq. in.	Pass No.	Area Sq. in.
Ingot	400	10	43.2
1	376.6	11	32.9
2	282.4	12	25.2
3	214.9	13	21.5
4	164.8	14	17.8
5	130.3	15	16.4
6	107.9	16	13.2
7	88.9	17	10.7
8	70.8	18	10.1
9	58.9		

The discards in pounds of the three test ingots were as follows:

	G1	G2	G3
Top of bloom	598	615	634
Bottom of bloom	628	533	403
Rail bar—top	138	141	139
Rail bar—1st intermediate crop	30	28	38
Rail bar—2d intermediate crop	105	100	123
Rail bar—bottom	70	69	55
Total discard	1569	1484	1392
Weight of 6 rails	6600	6600	6000
Total weight of ingot	8169	8084	7992

The discards sheared from the top of the ingot and the total croppings from the ingot are shown below, expressed in per cent.:

	G1 Per cent.	G2 Per cent.	G3 Per cent.
Discard from top	9.0	9.3	9.7
Total croppings	19.2	18.3	17.4

The rails at Gary are sawed with gang-saws, three or four rails being cut at one time. The spacing of the saws just previous to cutting the test rails measured 33 ft. 6⅜ in. for each of the three rails cut at one sawing. The length of the rails when cold and after straightening, and the camber of the rails before straightening are shown in the following table. These rails all had "base sweep," that is, they were concave on the head side.

Rail.	Length.	Camber.	Rail.	Length.	Camber.
G1 A	33 ft. 5/16 in.	3¾ in.	G2 D	33 ft. 3/16 in.	1½ in.
B	½ in.	4⅛	E	7/16 in.	3⅞
C		5⅜	F	⅜ in.	4¼
D	¼ in.	2⅛	G3 A	33 ft. ¼ in.	2⅛
E	½ in.	4¼	B	7/16 in.	2⅛
F	7/16 in.	4¼	C	3/16 in.	3⅜
G2 A	33 ft. 5/16 in.	2⅞	D	1/16 in.	1¼
B	½ in.	2⅞	E	⅜ in.	2¾
C	5/16 in.	4⅛	F	5/16 in.	2⅞

Temperature measurements were made of the head of the rail after leaving the finishing rolls by means of a Thwing radiation pyrometer, and I give below the readings obtained. How close these readings were to the actual temperature, I cannot say, although the instrument was new and probably in proper adjustment. Before rolling, the bloom was cut in two, three rails being rolled in one bar, and the table shows the temperature of both rail bars.

	G1	G2	G3
1st bloom	895° C.	910° C.	900° C.
2d bloom	890° C.	905° C.	905° C.

Before rolling these rails the mill had been shut down a while, and the above temperatures are about 50° C. lower than they had been running, as shown by some readings taken previous to the rolling of these rails, and also as shown by the length of the cold rails, which were about ¼-in. too long.

Pieces were cut from each rail of ingot G1 for tests as listed below, the pieces being cut in order from the top and as shown.

18 in.—Chemical analysis, etching and tensile tests.
4½ ft.—Drop test—head in tension.
4½ ft.—Drop test—base in tension.
4½ ft.—Bending test—head in tension.
4½ ft.—Bending test—base in tension.

The rails were made at Gary, but those from ingot G1 were shipped to South Chicago, where they were tested. The analyses of the mixer metal and of the ladle test were made at Gary, and the analyses of the rails were made at South Chicago.

CHEMICAL ANALYSES.

Analyses were made at South Chicago of two samples from near the top end of each rail, as shown in Fig. 1, one sample from the upper corner of the head and the other from the web. These analyses are

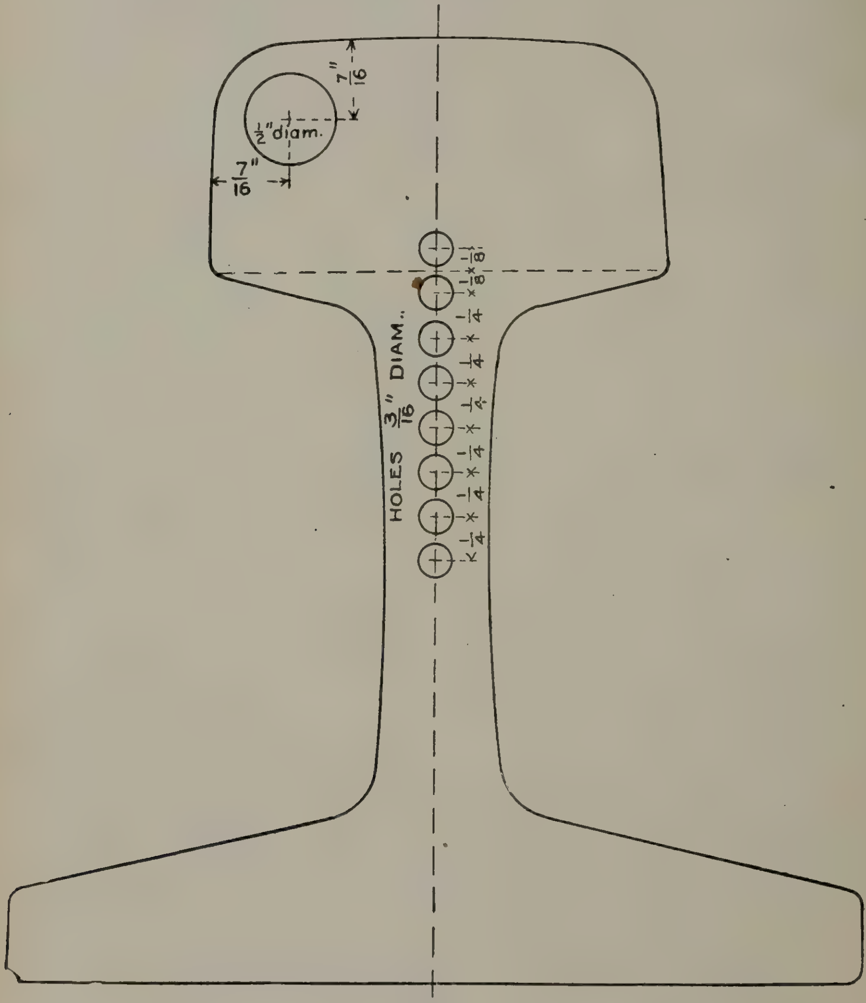


FIG. 1

shown in the table below. The average of the samples from the corner of the head should be about the average metal of the heat, and I show this average, as well as the ladle test made at Gary. This figure is also used below to determine the percentage of segregation.

Rail.	Carb.	Phos.	Sulph.	Mang.	Sil.
A—Head	.69	.045	.031	.76	.219
Web	.87	.048	.043	.80	.230
B—Head	.74	.042	.039	.75	.224
Web	.79	.055	.046	.83	.232
C—Head	.75	.040	.040	.81	.234
Web	.77	.042	.040	.80	.220
D—Head	.76	.038	.037	.81	.226
Web	.73	.038	.037	.79	.222
E—Head	.74	.050	.038	.87	.210
Web	.71	.048	.039	.80	.220
F—Head	.75	.041	.038	.82	.212
Web	.69	.040	.040	.81	.208
Av. hd. samples	.74	.043	.037	.80	.221
Ladle test (Gary)	.72	.036	.036	.72	.20

In the above table the carbon shows about 18 per cent. segregation in the web of the A rail, showing .87 per cent. in the web, as against an average of the steel of about .74 per cent. Another point of special interest in the A rail is the low carbon in the corner of the head, which seems to show a little negative segregation at that place, this place showing .69 per cent. carbon, as against an average of .74 per cent., or about 7 per cent. negative segregration. This is interesting, as showing that we have in the center of the A rail, at its top end, about the highest carbon in the ingot, while at the same time the outer portions of the section contain about the lowest carbon in the ingot, the variation being from .87 to .69 per cent. The samples from the upper corner of the head from the other rails of the ingot show just about the average carbon. The samples from the web show decreasing amounts of carbon as we go down the ingot. In the D rail about the average carbon is shown, while the E and F rails show slight negative segregation in the web, amounting to 7 per cent. in the top end of the F rail. The results on phosphorus are very irregular and show no very great segregation, although there is a suggestion of a little increase in the middle of the two upper rails, the highest being in the web of the B rail. The sulphur is fairly evenly distributed, but shows a little increase in the web of the A and B rails. Curiously enough, there is also some negative segregation in the upper corner of the head of the A rail, corresponding to a similar result on carbon, although the web of the F rail does not show negative segregation of sulphur. The amounts of segregation of the carbon, phosphorus and sulphur are shown in the following table:

	C.	P.	S.
Average of head samples.....	.74	.043	.037
Web of A rail..............	.87	....	....
Web of B rail..............	...	.055	.046
Increase	18%	28%	24%

The manganese and silicon are fairly evenly distributed and show no special segregation. For more convenient comparison the carbon, phosphorus and sulphur are retabulated below:

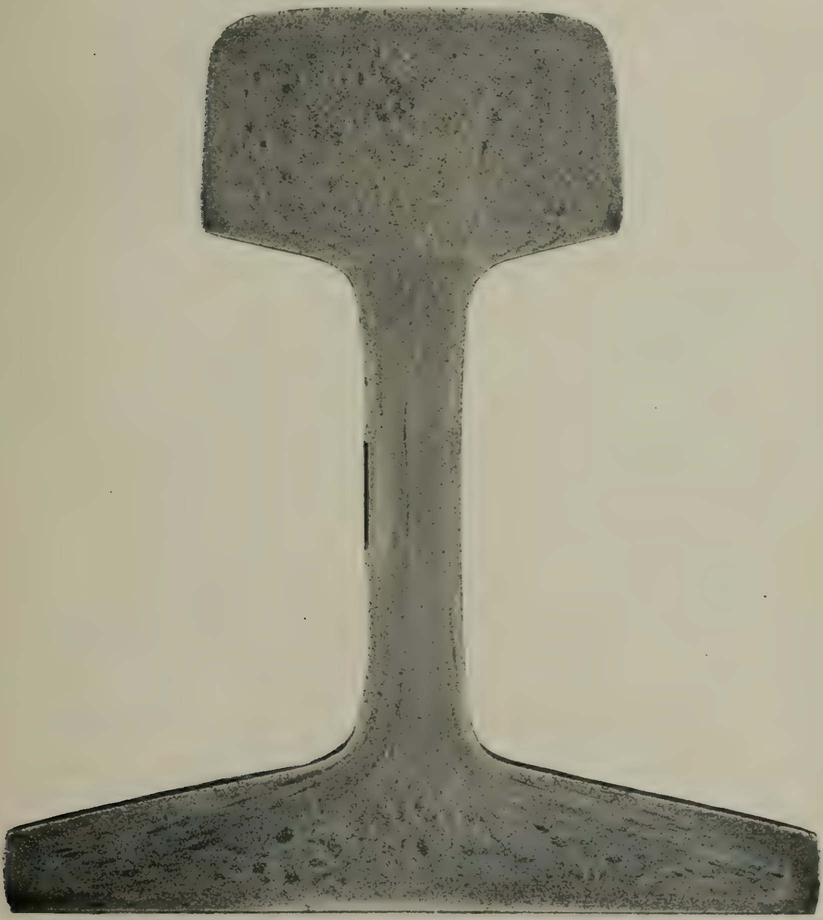
	Carbon.		Phosphorus.		Sulphur.	
Rail.	Head.	Web.	Head.	Web.	Head.	Web.
A	.69	.87	.045	.048	.031	.043
B	.74	.79	.042	.055	.039	.046
C	.75	.77	.040	.042	.040	.040
D	.76	.73	.038	.038	.037	.037
E	.74	.71	.050	.048	.038	.039
F	.75	.69	.041	.040	.038	.040
Av. head samples	.74		.043		.037	
Ladle test (Gary)	.72		.036		.036	

ETCHING.

Sections were cut from near the tops of each rail, polished and etched with a solution of copper ammonium chloride. The A rail shows some spots and streaks, but the other rails show an even structure. Photographs of the etched sections of the A and B rails are reproduced in Figs. 2 and 3. The C, D, E and F rails were very similar in appearance to the B rail, but are not reproduced.

TENSILE TESTS.

Tensile tests were made of pieces ½-in. diameter by 2-in. gauge length, cut from near the top end of each rail, as shown in Fig. 4. Five locations in the sections were selected as shown, and tests were made in duplicate, the bar being cut sufficiently long to make two test pieces. The yield point was determined by means of a Capp's multiplying divider, which method gives a result somewhat above the elastic limit, but which, however, is probably sufficiently definite to make it desirable to determine it, and is not subject to the irregularities of the yield point as determined by the drop of the beam of the test machine, or even by ordinary dividers. The test pieces were very close to ½-in. diameter at the center, but toward the ends of the gauge length most of them were from .002 to .004 in. larger in diameter. This would tend to make the elongation less than if the diameter were perfectly uniform, but I am unable to state how much the result obtained was affected.



G1A3 - Etched with
copper ammonium
chloride.

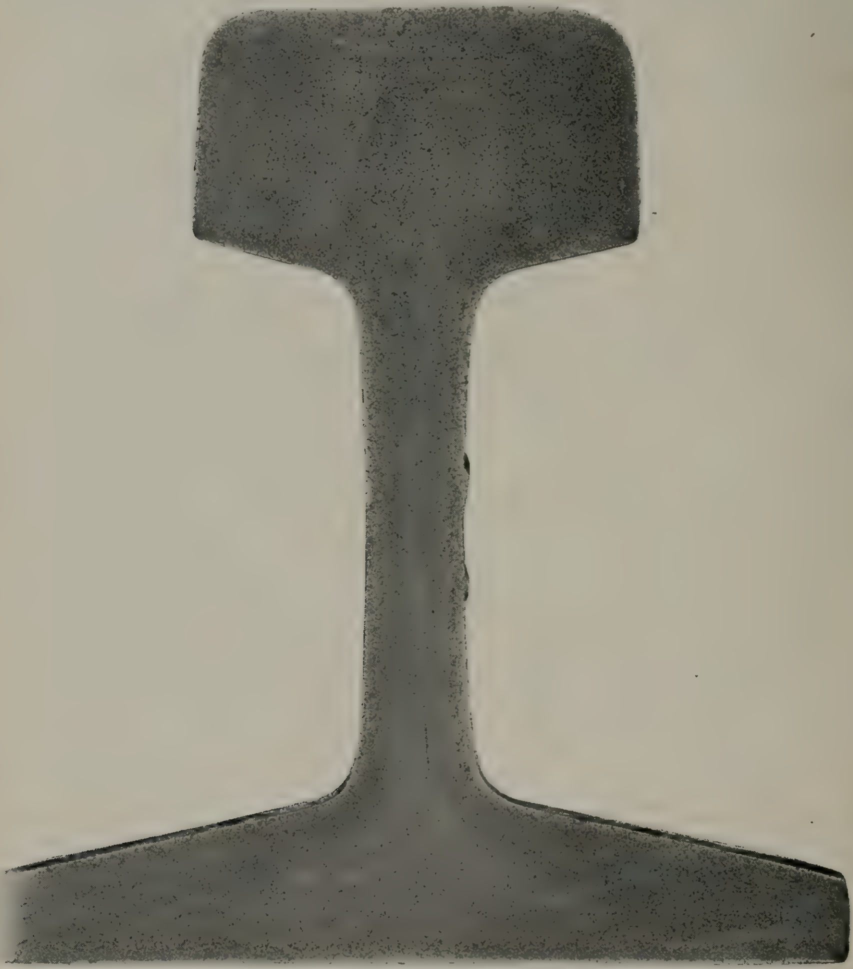
FIG. 2

The results of the tensile tests are shown in the following table:

Rail.	Location.	Yield Point lbs. per sq. in.	Tensile Str. lbs. per sq. in.	Ratio.	Elong. per cent. in 2 in.	Reduction of area per cent.
A	a—head, cor.	63,930	124,800	51	10	15
		61,640	125,800	49	9.5	19
	b—head, int.	69,510	134,400	52	8	12
		70,020	133,900	52	9	16
	c—web	.....	134,900	..	7	8
		73,060	141,000	52	9	10
	d—flange	65,960	121,700	54	14	26
		65,960	123,300	54	12	21
	e—base	60,890	109,600	..	3.5	2
		56,820	120,200	47	11	19
B	a—head, cor.	63,420	128,800	49	11.5	20
		65,690	128,300	51	11	19
	b—head, int.	66,970	......	..	1.5	2
		68,220	135,900	50	9	16
	c—web	70,310	137,000	51	11	19
		70,010	137,000	51	9.5	19
	d—flange	66,970	132,900	50	10.5	19
		65,690	129,800	51	12	23
	e—base	64,940	129,400	50	10	19
		63,930	126,800	50	10	16
C	a—head, cor.	67,710	130,900	52	11.5	22
		65,690	......	..	3	3
	b—head, int.	66,970	132,900	50	10	16
		69,230	133,400	52	10	17
	c—web	66,970	133,900	50	11	20
		66,230	133,900	50	11.5	21
	d—flange	66,490	132,900	50	12.5	26
		67,480	133,400	51	12.5	27
	e—base	64,170	128,300	50	10.5	19
		64,170	128,800	50	11	19

Rail.	Location.	Yield Point lbs. per sq. in.	Tensile Str. lbs. per sq. in.	Ratio.	Elong. per cent. in 2 in.	Reduction of area per cent.
D	a—head, cor.	67,990	132,400	51	12	19
		68,720	130,900	52	11	21
	b—head, int.	64,940	129,300	50	11	16
		65,930	128,300	52	11	21
	c—web	66,930	130,800	51	11	24
		66,970	131,900	51	11.5	23
	d—flange	70,020	133,900	52	13	28
		70,460	134,400	52	12.5	27
	e—base	65,690	130,900	50	10	20
		69,290	132,400	52	10.5	19
E	a—head, cor.	66,740	127,900	52	11	19
		......	125,300	..	11	19
	b—head, int.	63,920	124,800	51	11	20
		64,180	124,300	52	11	21
	c—web	64,940	128,900	50	12.5	25
		66,460	128,900	52	12	23
	d—flange	67,440	131,800	51	12	26
		68,220	132,400	52	12	25
	e—base	68,220	129,800	53	11	20
		69,510	130,400	53	10.5	19
F	a—head, cor.	65,210	128,400	51	12	19
		63,420	128,300	50	12	20
	b—head, int.	60,900	120,800	50	12	22
		66,500	123,700	54	12	21
	c—web	64,680	125,300	52	13	25
		64,180	125,800	51	13	25
	d—flange	70,020	132,400	53	11.5	27
		67,710	131,900	51	12.5	21
	e—base	63,670	127,300	50	11	20
		68,950	128,300	54	11	20

The duplicates agree well with each other except in a few cases where the test pieces broke "short" as follows: One sample from base of the A rail, one sample from the interior of the head of the B rail and one sample from the corner of the head of the C rail. One sample from the web of the A rail should probably also be classed here. The duplicates from the lower rails of the ingot agree partic-



G1B3-Etched with copper ammonium chloride.

FIG. 3.

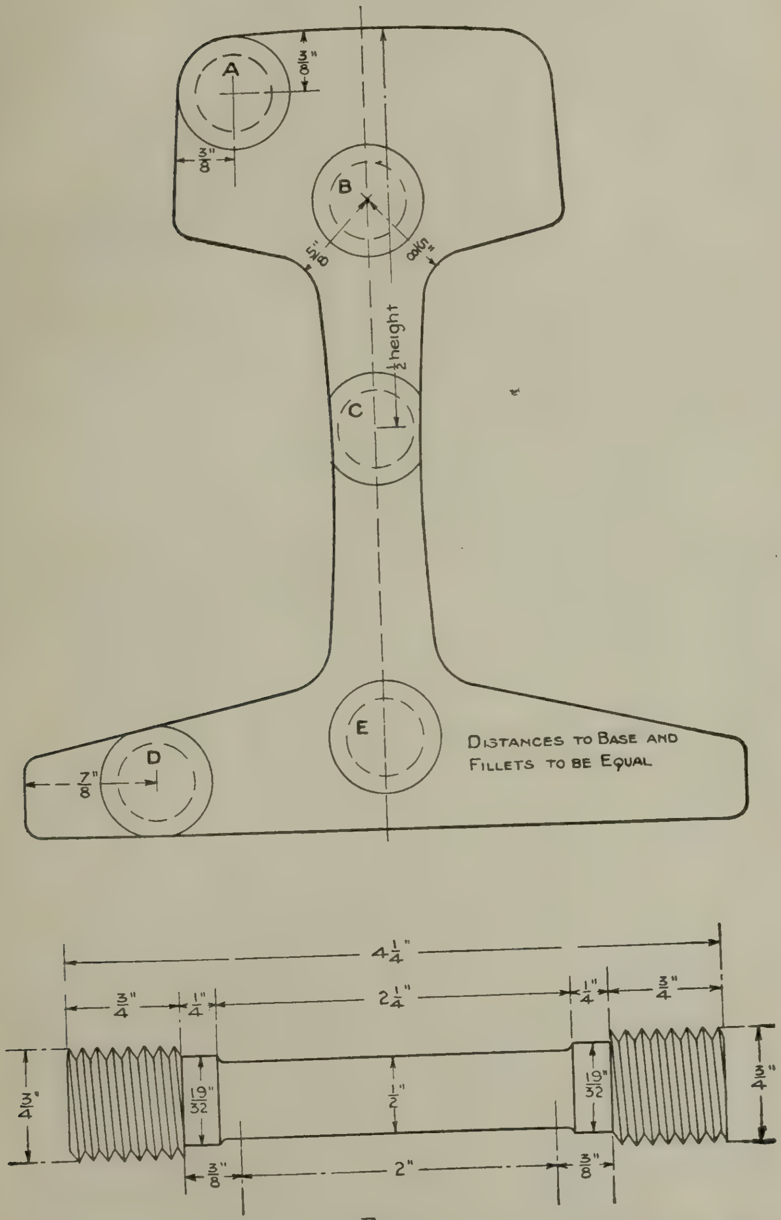


FIG. 4

ularly well, indicating a freedom from local irregularities. The ratio of the yield point to the tensile strength averages about

51 per cent., and most specimens differ but little from this figure. A comparison of the tensile strength is interesting, and I give below a table showing the tensile results, showing the tensile strength of the sample in each pair that gave the greatest ductility.

Rail.	a—head, corner.	b—head, interior.	c—web.	d—flange.	e—base.
A	124,800	133,900	141,000	121,700	120,200
B	128,800	135,900	137,000	129,800	129,400
C	130,900	133,400	133,900	133,400	128,800
D	132,400	128,300	131,900	133,900	132,400
E	127,900	124,300	128,900	131,800	129,800
F	128,300	120,800	125,300	131,900	128,300
Aver.	128,800	129,400	133,000	130,400	128,200

The b samples from the interior of the head and the c sample from the web represent what was originally the interior of the ingot, and in the A rail these samples show strengths much higher than the samples from the other parts of the section representing what was the outer part of the ingot. This is also true of the B rail, but to a less extent, and also of the C rail to a slight extent. As we continue down the ingot, however, conditions are reversed, and we find in the D rail a little lower strength in the samples from the interior than in the samples representing what was the outer portion of the ingot. This difference is greater in the E rail and greatest in the F rail. This corresponds with what we have already noted above concerning the distribution of the carbon in the ingot, namely, that in the interior it decreases from the top downward.

The A rail also shows another striking feature. We have already seen that the outer part of the section of this rail shows a negative segregation of carbon, and this condition is also reflected in the results of the tensile tests. The average tensile strength of all the "outer" samples is 129,100 lbs. per sq. in., which may be called the strength of the average metal of the ingot. In all the rails except the A rail, the outer samples approximate this strength, but in the A rail the outer samples fall considerably under this figure, which agrees with the results of the analysis. The base shows a strength of 120,200, which is the lowest in the table. As the center portion of the web showed a strength of 141,000, which is the highest result obtained, the top of the A rail contains both the metal of maximum and of minimum tensile strength, and this difference corresponds to the difference found in carbon.

The a sample from the corner of the head and the d sample from the flange would be metal of similar chemistry, but the flange has a considerably lower finishing temperature and is also reduced differently, and I give below a table comparing the results from these two places.

	Tensile Strength per sq. in.		Elongation. in 2 in.		Reduction of area.	
Rail	a	d	a	d	a	d
A	124,800	121,700	10%	14%	15%	26%
B	128,800	129,800	11.5	12	20	23
C	130,900	133,400	11.5	12.5	22	27
D	132,400	133,900	12	13	19	28
E	127,900	131,800	11	12	19	26
F	128,300	131,900	12	12.5	20	21
Av. B to F	129,700	132,200	11.6	12.4	20	25

The d sample from the flange of the A rail is abnormal with a low strength and high ductility, being evidently taken at a point of negative segregation of carbon, but except for this sample, the d samples from the flange show a little higher strength and also a little greater ductility. As the difference in the work of rolling is perhaps sufficient to account for this, the conclusion seems to be that the difference in rolling temperature has not resulted in any important difference in the tensile properties.

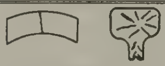
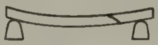
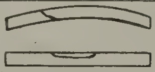
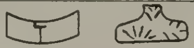
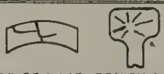
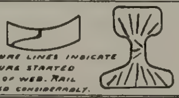
The b sample from the interior of the head and the c sample from the web would be of similar chemistry, as representing the interior of the ingot, but the web is thinner and gets more work in rolling and probably is finished at a lower temperature. A comparison of these two locations is shown below:

	Tensile Strength per sq. in.		Elongation in 2 in.		Reduction of area.	
Rail.	b	c	b	c	b	c
A	133,900	141,000	9%	9%	16%	10%
B	135,900	137,000	9	11	16	19
C	133,400	133,900	10	11.5	17	21
D	128,300	131,900	11	11.5	21	23
E	124,300	128,900	11	12.5	21	25
F	120,800	125,300	12	13	22	25
Av. B to F	128,500	131,400	10.6	11.9	19.4	22.6

In the A rail it is probable that the carbon is higher in the web sample than in the head sample, but in the other rails there probably are no great differences, and the averages I show above are of the B to F rails inclusive. The tensile strength of course decreases as we go down the ingot and the ductility increases, as we have already seen above. The web samples, as compared with the head samples, show a little greater strength, an average of 131,400 lbs., as against 128,500 lbs., and also a little greater ductility, an average elongation of 11.9 per cent., as against 10.6 per cent., and a reduction of area of 22.6 per cent., as against 19.4 per cent. This difference, it would seem, is probably due to the increased work in rolling that the web gets. It is also interesting to note that the top rails show as good ductility in the head samples as the lower rails, allowing, of course, for the difference in tensile strength, which would make about 3 per cent. decrease in elongation for an increase in tensile strength of 10,000 lbs.

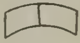
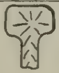
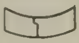
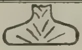
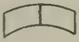
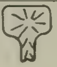
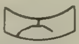
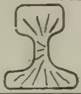
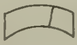
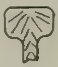
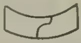
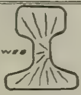
DROP TESTS.

Two drop tests were made of each rail, one with the head in tension and the other with the base in tension, with results as shown in the tables, which show the deflections of the rails, the elongations of the metal on the side in tension, and diagrams of the fractures.

TEST NUMBER	HEAD OR BASE IN TENSION	HEIGHT OF DROP	NUMBER OF BLOW	DEFLECTION	1" MARKS AFTER BLOW $\frac{1}{100}$ THS.						REMARKS
					1	2	3	4	5	6	
G1A4	HD.	19'-9"	1	BROKE	102	103	104	103	103	101	 FRACTURE SHOWED AREA OF FINER STRUCTURE IN WEB
G1A5	BASE	"	1	BROKE	100	101	102	101	101	101	FRACTURE SHOWED AREA OF FINER STRUCTURE IN WEB "SHEAR" BREAK  RAIL ROCKED ON SUPPORTS.
G1B4	HD.	"	1	BROKE	103	103	105	106	105	103	 FRACTURE LINES INDICATE THAT BREAK WAS FROM COMPRESSION SIDE PIECE OF FLANGE BROKE OUT BY TUP. UNIFORM CRYSTALLINE FRACTURE.
G1B5	BASE	"	1	1.44	103	103	104	105	104	104	 UNIFORM CRYSTALLINE FRACTURE
			2	2.50	104	104	105	107	109	110	
			3	3.56	106	108	112	115	115	112	
			4	BROKE	111	114	119	118	115	112	
G1C4	HD.	"	1	1.35	104	105	106	107	107	105	 PIECE OF BASE BROKEN OUT ON 3RD BLOW DUE TO HOLLOW DIE.
			2	2.60	106	109	114	115	113	109	
			3	3.66	108	113	118	119	116	111	
			4	BROKE	108		117	118	116	111	
G1C5	BASE	"	1	1.32	103	103	104	104	104	104	 FRACTURE LINES INDICATE FRACTURE STARTED MIDDLE OF WEB. RAIL BUCKLED CONSIDERABLY.
			2	2.46	105	106	108	108	108	107	
			3	BROKE	106	108	109	110	109	107	

In the tests of the A, B and C rails the tup was 2,030 lbs. and height of drop 19 ft. 9 in., which is about equivalent to a tup of 2,000 lbs. with a height of 20 ft. In the tests of the D, E and F rails the tup was 2,000 lbs. and the height of drop was 20 ft. The standard spring-supported anvil was used, with rail supports 3 ft. apart. Unfortunately, the striking die of the tup and the rail supports were in rather worn condition in the tests of the A, B and C rails, and undoubtedly the nature of the fracture was largely determined by this condition of the test apparatus in the test of the A rail with base in tension and of the B rail with head in tension, both of which broke on the first blow. The A rail with head in tension also broke on the first blow, but the nature of the fracture shows that the break was not influenced in this case by the condition of the supports and striking die.

The results showing the deflection after the first blow and the maximum elongation of the metal in tension are compared in the following table. In figuring the averages, the results where the rail broke on the first blow, are excluded.

TEST NUMBER	HEAD or BASE IN TENSION	HEIGHT OF DROP	NUMBER OF BLOW	DEFLECTION	1" MARKS AFTER BLOW $\frac{1}{100}$ THS.						REMARKS
					1	2	3	4	5	6	
G1 D4	HD.	20'	1	1.42	1.03	1.04	1.06	1.07	1.06	1.05	 
			2	2.64	1.07	110	1.15	1.16	1.13	1.09	
			3	BROKE	1.07	1.12	1.19	121	1.14	1.09	
G1 D5	BASE	20	1	1.98	1.03	103	1.04	1.04	1.04	1.03	 
			2	2.88	1.06	1.08	1.10	1.10	1.09	1.06	
			3	3.66	111	115	1.17	116	1.11	1.08	
			4	BROKE	112		1.20	1.19	1.13	1.08	
G1 E4	HD.	20	1	1.52	1.05	1.07	1.08	1.06	1.05	1.04	 
			2	2.72	1.09	1.15	1.16	1.15	1.09	1.05	
			3	BROKE	1.10	1.17	1.21	1.21	1.13	1.08	
G1 E5	BASE	20	1	1.50	1.04	1.05	1.05	1.05	1.04	1.03	 
			2	2.62	1.08	1.11	1.11	1.11	1.07	1.05	
			3	3.76	1.12	1.15	1.16	1.13	1.11	1.06	
			4	BROKE	1.12	1.16	1.17	1.15	1.12	1.08	FRACTURE LINES INDICATE THAT BREAK STARTED IN WEB.
G1 F4	HD.	20	1	1.57	1.04	1.05	1.07	1.07	1.07	1.06	 
			2	2.76	1.05	1.08	1.12	1.16	1.16	1.12	
			[illegible]	BROKE	1.05	1.08	112	116	1.16	1.12	
G1 F5	BASE	20	1	1 52	1.03	1 03	1.04	1.04	1.04	1.04	 
			2	2.68	1.05	1.05	1.07	1.11	1.11	1.09	
			3	3.88	1 05	1.07	1.10	1.14	1.15	1.14	FRACTURE STARTED IN WEB RAIL BUCKLED BEFORE BREAKING.
			4	BROKE	1.05	1.07		1.13	1.15	1.14	

	Elongation—1st blow.		Deflection—1st blow.	
Rail.	Head Tension	Base	Head	Base.
A	4% broke.	... broke.	....	....
B	... broke.	5%	....	1.44 in.
C	7	4	1.35 in.	1.32
D	7	4	1.42	1.48
E	8	5	1.52	1.50
F	7	4	1.57	1.52
Average	7.3%	4.4%	1.46 in.	1.45 in.

It will be noted that the deflection is about the same with either the head or base in tension, but the maximum stretch of the metal is 66 per cent. greater when the head is in tension. In a general way, also, the deflection of the rail increases as we go down the ingot, showing the upper rails to be stiffer, which agrees with the indications of both the chemical and tensile tests. The figures for deflection are not complete in the above table, but roughly the upper rails may be said to be about 20 per cent. stiffer than the bottom rail, as measured by the deflection under a drop of 20 ft.

I give below a table showing the maximum elongations obtained under successive blows when the rail did not break as a result of the blow:

	Elongation—Head Tension.			Elongation—Base Tension.		
Rail.	1st blow.	2d blow.	3d blow.	1st blow.	2d blow.	3d blow.
A	..	..	..	..	..	..
B	..	..	..	5%	10%	15%
C	7%	15%	19%	4	8	..
D	7	16	..	4	10	17
E	8	16	..	5	11	16
F	7	16	..	4	11	15
Aver.	7.3	15.8		4.4	10	15.8

This table is useful in calculating from the elongation which the metal gave at fracture, the approximate height of blow which would be just sufficient to cause fracture, and will be so used below.

The number of blows which broke the rails and the maximum elongations obtained are shown in the following table:

	Maximum Elongation.		No. of Blows.	
Rail.	Head Tension.	Base Tension.	Head Tension.	Base Tension.
A	4%	..	1	1
B	..	19	1	4
C	19	10	4	3
D	21	20	3	4
E	21	17	3	4
F	16	15	3	4

The A rail, both with head tension and with base tension, and the B rail, with head tension, broke on the first blow. In the two latter tests the failure was probably due in part, as explained above, to the condition of the rail supports and striking die, but in the test of the A rail with head tension, the break was a square one where hit, and the test was a fair one. The average maximum elongation of the metal with head tension after the first blow, when failure did not occur, was 7.3 per cent., and as the A rail with head tension broke at 4 per cent. elongation, we may figure roughly that this rail would have just broken with a drop of about 11 ft. Figuring in a somewhat similar manner, and using the table of elongations under successive blows given above, I show below the approximate height that the tup would have to fall from to just cause fracture of the rails. I have taken the elongation at the last blow which did not cause failure and assumed each additional per cent. elongation above this was due to an additional drop of 2.5 ft. in head tension and 3.8 ft. in base tension.

Rail.	Head Tension.	Base Tension.
A	11 ft.	..
B	..	75 ft.
C	60	48
D	53	71
E	53	71
F	40	60

If given in one blow of full height, instead of several blows of lesser height, the above heights would have to be lessened by ½-ft. for each blow less in number than was actually used, as calculation shows that about ½-ft. drop of a 2,000-lb. weight is absorbed within the elastic limit.

A study of the fracture lines shows that with the head in tension, the fracture started from a point near the middle of the head in all cases except the F rail, where the fracture seems to have started from near the top of the head. With the base in tension, in three of the six tests, the fracture started in the web, due, evidently, to the sidewise buckling. In the other cases it seems to have started near the bottom of the base.

BENDING TESTS.

Two pieces, 4½ ft. long, were cut from each rail for bending in the test machine, one being bent with the head in tension and the other with the base in tension, using a span of 3 ft. The supports were flat surfaces, whose edges were 3 ft. apart. Only sufficient load was put on to give the rails a permanent set. The deflections were determined by measuring the distance between the under side of the rail and a block on the weighing platform of the test machine, using a deflectometer reading to .001 inch. This method is not entirely satisfactory, as the deflection so obtained includes the drop of the rail adjusting itself to the supports, the compression of the supports, etc., but it allows an approximate determination of the elastic limit. The deflections in inches are shown in the following tables, the heading "Head" or "Base" referring to the part in tension.

	G1 A		G1 B		G1 C	
Load.	Head.	Base.	Head.	Base.	Head.	Base.
20,000	.036	.023	.028	.032	.040	.031
40,000	.060	.047	.064	.057	.068	.057
60,000	.085	.072	.088	.085	.093	.086
80,000	.110	.098	.114	.114	.119	.119
90,000	.125	.110	.128	.130	.133	.135
100,000	.140	.125	.143	.146	.147	.153
105,000	.148	.132	.151	.154	.155	.161
110,000	.157	.140	.160	.163	.163	.170
115,000	.168	.149	.170	.173	.170	.180
120,000	.180	.159	.180	.183	.179	.191
125,000	.193	.168	.192	.194	.190	.203
130,000	.209	.179	.207	.207	.199	.213
135,000	...	...	.224	.220	.210	.227
140,000	.250	.210	.242	.240	.236	.243
150,000	.303	.255	.295	.289	.262	.290

	G1 D		G1 E		G1 F	
Load.	Head.	Base.	Head.	Base.	Head.	Base.
20,000	.030	.034	.032	.029	.032	.028
40,000	.055	.064	.060	.058	.055	.054
60,000	.080	.097	.084	.089	.079	.085
80,000	.105	.132	.112	.124	.104	.116
100,000	.134	.169	.140	.163	.134	.152
105,000	.143	.178	.152	.173	.143	.161
110,000	.153	.189	.159	.184	.152	.171
115,000	.164	.199	.169	.194	.163	.182
120,000	.174	.210	.180	.207	.175	.194
125,000	.187	.222	.195	.221	.192	.207
130,000	.203	.236	.212	.236	.209	.225
135,000	.223	.251	.232	.254	.234	.247
140,000	.244	.266	.254	.278	.261	.276
150,000	.301	.313	.314	.333	.325	.340

The load deflection diagrams plotted from these tables are shown as Fig. 5. The elastic limit is not sharply defined on these curves, partly because of the faulty method of getting the deflections, as explained above, and partly, I presume, because the elastic limit probably is not very sharply defined with a bending load. Roughly, the elastic limit with a 3-ft. span with the base in tension seems to be about 130,000 lbs. for all the rails. With the head in tension, it seems to be about the same for B and C rails, but for the other rails seems to be about 5,000 or 10,000 lbs. lower. The elastic limit of the A rail with head in tension, as indicated by the diagram, is indeed only 115,000 lbs. This is curious, but is at least partly accounted for when we remember that we found the carbon and the tensile strength low in the outer portions of the section of this rail.

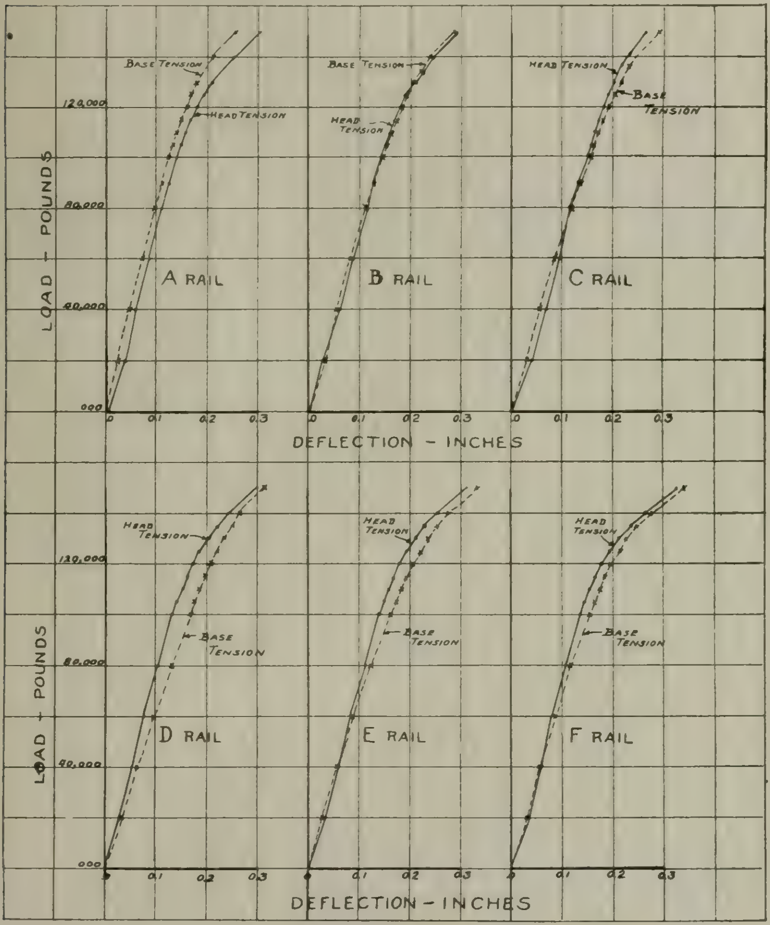


FIG. 5

Finally I wish to state that the thanks of the Rail Committee are due to the officers of the Steel Company for the use of their facilities for making the tests described above and for the considerable help given me in making the tests.

TESTS OF BESSEMER RAILS—EDGAR THOMSON WORKS OF THE CARNEGIE STEEL CO., 90 LB. A. R. A. TYPE B

By M. H. WICKHORST, Engineer of Tests, Rail Committee.

This report covers tests of some 90-lb. Bessemer rails, A. R. A. type B, made at the Edgar Thomson Works at Braddock, Pa., of the Carnegie Steel Company, July 26, 1910, Carnegie section 90 R. B. Heat 3043.

MANUFACTURE.

Lake Superior ore was used. The iron from the blast furnaces was poured into a mixer, from which it was weighed into a ladle. The metal was then poured into the converter, scrap added, blown with 17 lbs. pressure, and poured into the teeming ladle, liquid spiegel being poured into the ladle at the same time. There were no other additions. From here the metal was poured into the molds through a 1¾-in. nozzle. The amounts of the materials used were as follows:

Mixer metal	34,100 lbs.
Scrap steel	2,000 lbs.
Spiegel	3,445 lbs.

Samples of the mixer metal and spiegel gave the following results on analysis:

	Carb.	Phos.	Sulph.	Mang.	Sil.
Mixer metal	3.86	.096	.040	.79	1.55
Spiegel	4.42	.124	.016	12.05	.92

The operations occurred at the following times:

Started blowing	11:49½ a. m.
Finished blowing	12:06 p. m.
Time used to blow	17½ minutes
Started to pour into the ladle	12:06 p. m.
Started to pour into the molds	12:10 p. m.
Time from finish of blowing to start of pouring into molds	4 minutes
Finished pouring into the molds	12:17 p. m.

Report No. 6, August, 1910.

The heat made seven ingots with an average weight of 5,207 lbs. The molds were 18½x19½ in. at the bottom, 17½x18½ in. at the top and 70 in. high, and the ingots were about 63 in. high. The stools and molds were sprayed with clay wash and, directly after pouring, the ingots were covered with about one-half shovelful (about 1½ lbs.) of fire clay. The ladle test was taken at the end of the pouring of the second ingot. Three ingots were taken for the test rails, namely, the 2d, 3d and 4th of the pouring, and were given test numbers ET1, ET2 and ET3. The ingots were in the soaking pits from 1:07 p. m. to 2:43 p. m., or 1 hr. 36 min. The temperature, as determined with a Thwing radiation pyrometer pointed at the side of the ingot in the pit through the peep hole at 2:20 p. m., was 1,210° C. The ingots were bloomed to 9½x9½ in. in seven passes and cut into two blooms, croppings being sheared from the top and bottom. The blooms were then put into reheating furnaces from 2:46 p. m. to 3:04 p. m., or 18 min., and then rolled into rails in 13 passes, making a total of 20 passes from ingot to rail. The total reduction was from 328 sq. in. at the top of the ingot to 9 sq. in., or 36 times. The areas of the various passes, as furnished by the Steel Company, were as follows:

	Area.	Pass.	Area.
Ingot, bottom	350	10	54.1
Ingot, top	328	11	45.0
Pass.		12	37.0
1	288.1	13	29.6
2	244.0	14	24.8
3	204.0	15	21.0
4	170.1	16	16.7
5	140.0	17	13.1
6	112.0	18	10.9
7	88.4	19	9.5
8	74.0	20	9.0
9	65.3		

The discards in pounds of the three test ingots were as follows:

	ET1	ET2	ET3
Bloom—top	850	785	755
Bloom—bottom	160	155	266
Rail bar—top	56	48	54
Rail bar—1st intermediate	35	47	45
Rail bar—2d intermediate	46	55	39
Rail bar—bottom	50	46	44
Total discard	1197	1136	1203
Weight of 4 rails	3992	3992	3992
Total weight of ingot	5189	5128	5195

The weight of the A rail of ingot ET1 was found to be 998 lbs. and the four rails of the ingots are shown above as 3992 lbs. The nominal weight would be 3960 lbs. The discards from the top of the ingot and the total discards are shown below, expressed in per cent.:

	ET1	ET2	ET3
Discard from top of ingot	17.4%	16.2%	15.6%
Total discard	23.1	22.2	23.2

The rails were sawed two at a time, the A and C rails with the front and middle saws and the B and D rails with the middle and back saws. The saw setting was 33 ft. 7 in. both front and back. The length of the rails and their camber when cold and before straightening are shown in the following table. The rails all had "base sweep," that is, they were concave on the head side. These rails also had a little side camber, being concave on the bottom side, that is, the side which was down in the rolling. The shrinkage averaged 7 in.

Rail.	Length.	Camber.	Rail.	Length.	Camber.
ET1A	33 ft. 0 in.	2½ in.	ET2C	33 ft. 1/16 in.	2¼ in.
B	33 ft. 0 in.	2⅝ in.	D	33 ft. 0 in.	2⅛ in.
C	33 ft. 0 in.	2½ in.	ET3A	33 ft. 1/16 in.	1⅝ in.
D	33 ft. ⅛ in.	2½ in.	B	32 ft. 11⅞ in.	2¼ in.
ET2A	33 ft. 0 in.	2½ in.	C	33 ft. 0 in.	1 in.
B	33 ft. 0 in.	2⅞ in.	D	32 ft. 11⅞ in.	2½ in.

Temperature measurements were made with a Thwing radiation pyrometer, of the head of the rail after leaving the finishing rolls, and I give below the readings obtained:

	ET1	ET2	ET3
1st bloom	990° C.	995° C.	990° C.
2d bloom	995° C.	995° C.	995° C.

The rails from ingots ET2 and ET3 were straightened and directed to be shipped to "A. W. Thompson—B. & O. R. R.—Cumberland, Md.," intended for test in track, the rails from one ingot to be used on the high rail of a curve and those from the other ingot on the low side. The rails from ingot ET1 were not straightened, but were cut up for tests as follows:

No. 1. 18 in.—Tensile tests, etching and analysis.
2. 4½ ft.—Drop test—head in tension.
3. 4½ ft.—Drop test—base in tension.
4. 4½ ft.—Bending test—head in tension.
5. 4½ ft.—Bending test—base in tension.
6. 10 ft.—For test on revolving machine at Steelton, Pa.
7. 3½ ft.—For test on reciprocating machine at Sparrows Point, Md.

CHEMICAL ANALYSES.

Analyses were made of two samples from near the top end of each rail, as shown in Fig. 1, one sample from near the upper corner of the head and the other from the web. These analyses, as furnished by the Steel Company, are shown in the following table. The average of the samples from the corner of the head should be about the average metal of the heat, and I show this average as well as the ladle test.

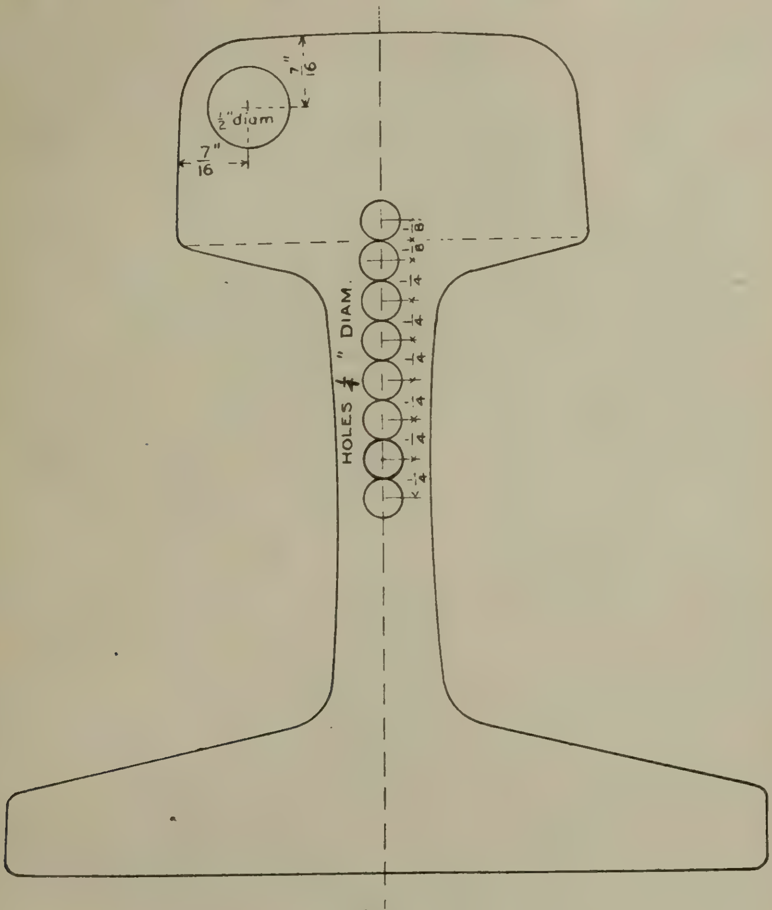


Fig. 1.

Rail.	Carb.	Phos.	Sulph.	Mang.	Sil.
A—Head	.52	.094	.037	1.16	.081
Web	.62	.168	.074	1.23	.084

Rail.	Carb.	Phos.	Sulph.	Mang.	Sil.
B—Head	.55	.106	.046	1.14	.084
Web	.57	.116	.048	1.14	.089
C—Head	.49	.104	.047	1.15	.084
Web	.49	.098	.042	1.11	.093
D—Head	.54	.103	.045	1.14	.084
Web	.45	.092	.038	1.14	.096
Av. hd. samples	.52	.102	.044	1.15	.083
Ladle test	.47	.100	.045	1.08	.088

In the above table the web sample of the A rail, representing the interior of the ingot, shows a marked increase of carbon, phosphorus and sulphur over the average of the head samples, which may be taken as representing about the average metal in the ingot, and it also shows a little increase of manganese. The B rail shows a small similar tendency as regards carbon and phosphorus. The C rail shows about the same chemistry in the outer and interior parts of the section. The interior of the D rail shows a little decrease in carbon and phosphorus and seems to show a similar tendency as regards sulphur. The silicon is fairly uniform throughout the ingot. The carbon, phosphorus and sulphur are retabulated below for more convenient comparison.

	Carbon.		Phosphorus.		Sulphur.	
Rail.	Head.	Web.	Head.	Web.	Head.	Web.
A	.52	.62	.094	.168	.037	.074
B	.55	.57	.106	.116	.046	.048
C	.49	.49	.104	.098	.047	.042
D	.54	.45	.103	.092	.045	.038
Av. head samples	.52		.102		.044	

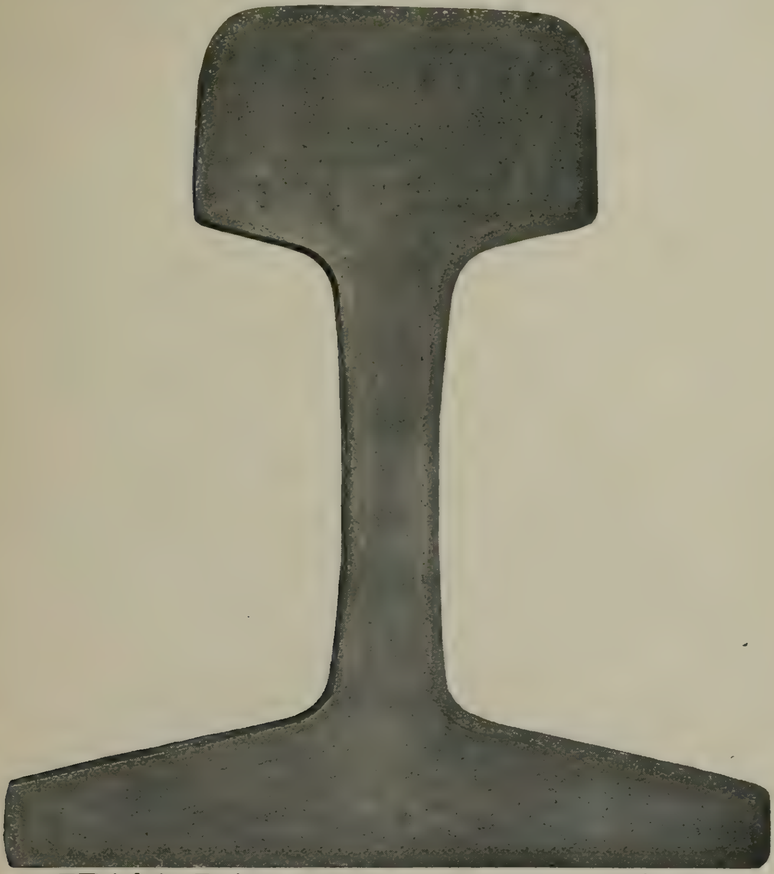
In the interior of the rail, as shown by the web samples, the carbon, phosphorus and sulphur are seen to decrease as we go down the ingot, the top showing positive segregation and the bottom showing a little negative segregation. It is also interesting to note that the top end of the A rail shows a little negative segregation of phosphorus and sulphur in the outer part of the section to about the same extent as the interior of the D rail, but the same result is not shown as regards the carbon.

The percentages of increase of the carbon, phosphorus, sulphur and manganese in the web of the A rail over the average of the ingot is shown in the following table:

	Carb.	Phos.	Sulph.	Mang.
Average of head samples...	.52	.102	.044	1.15
Web of A rail............	.62	.168	.074	1.23
Increase	19%	65%	68%	7%

ETCHING.

Sections were cut from near the top ends of each rail, polished and etched with a solution of copper-ammonium chloride. The A rail shows some spots and streaks distributed throughout the section. The B rail gave an even etching except for a few streaks in the web. The C and D rails gave even etchings over the whole section. The etchings of the A and B rails are reproduced as Figs. 2 and 3.

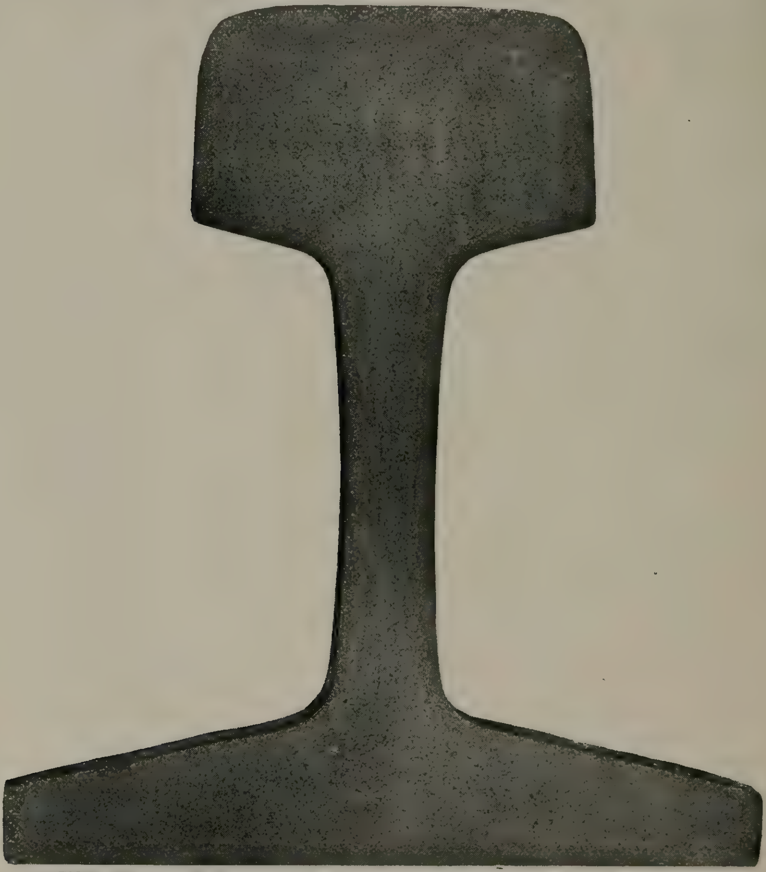


ET1A1 Etched with copper-ammonium chloride

Fig. 2.

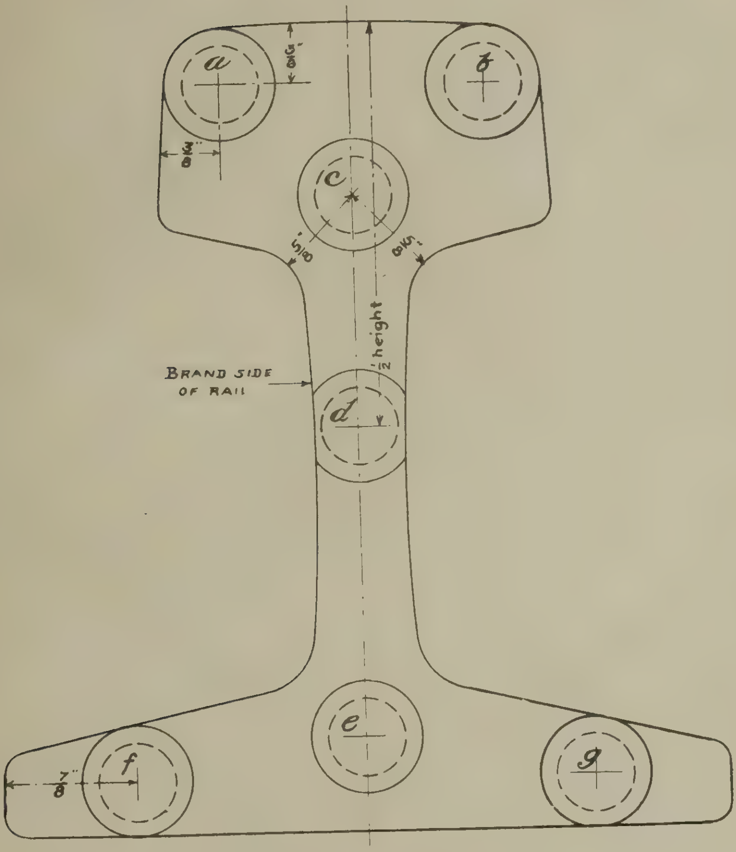
TENSILE TESTS.

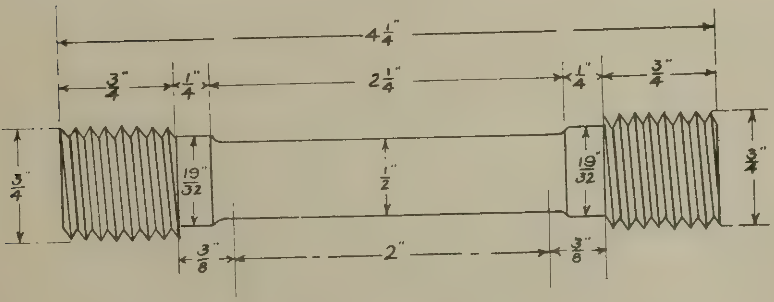
Tensile tests were made of pieces cut from near the top end of each rail, as shown in Figs. 4 and 5. Seven locations in the section were selected for longitudinal tests, the pieces being ½-in. diameter by 2 in. gauge length, and one location was selected for transverse test, namely, across the center of the head, this piece being ½-in. diameter by 1 in. gauge length. All pieces were tested in duplicate. The yield point was determined by means of a Capp's multiplying dividers, except with the 1-in. gauge length, where ordinary dividers and the drop of the beam were used.



ET 1 B1 Etched with copper-ammonium chloride

FIG. 3.


a
b
c
d
e
f
g
3"/8
3"/8
5/8
5/8"
½ height
BRAND SIDE OF RAIL
7"/8


4¼"
3"/4
1"/4
2¼"
1"/4
3"/4
3"/4
19"/32
½"
19"/32
3"/4
3"/8
2"
3"/8

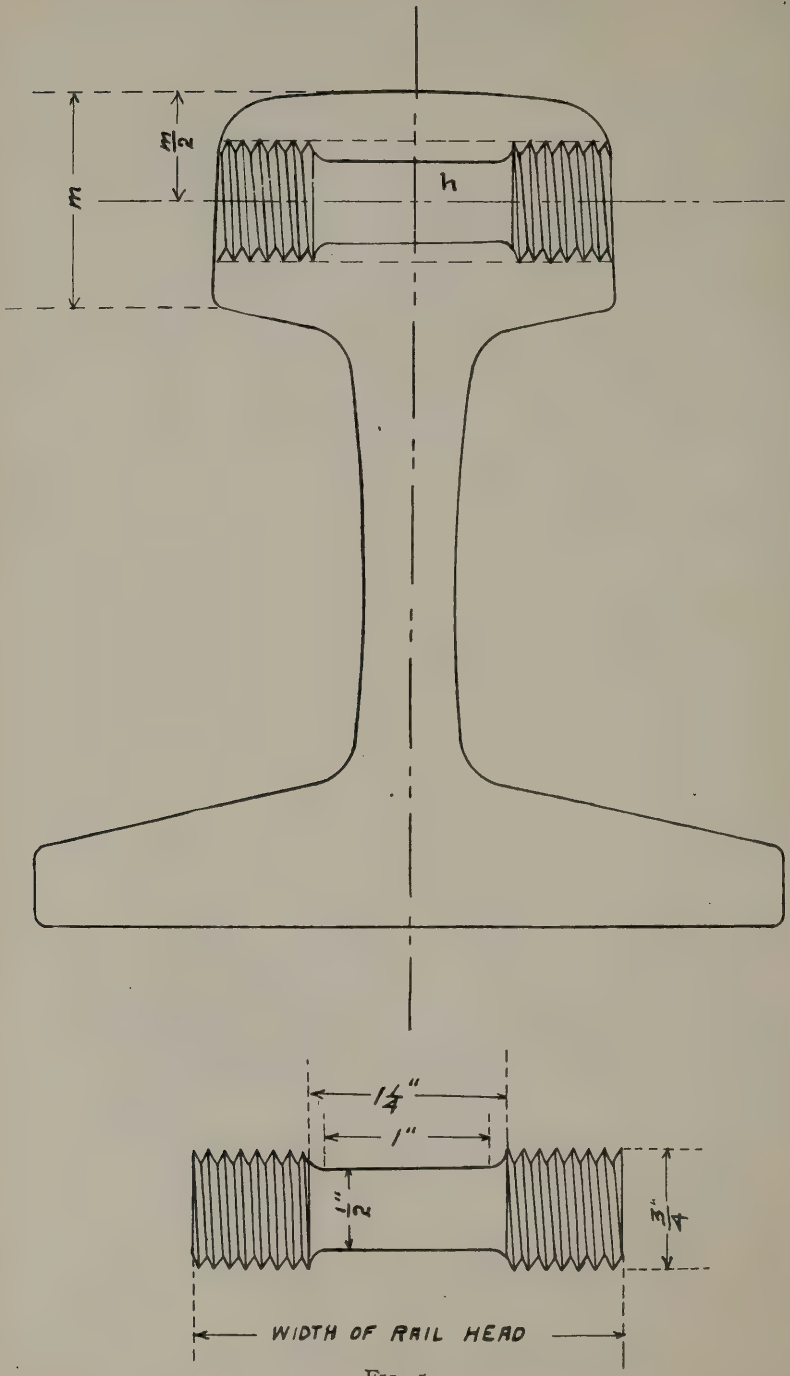


Fig. 5.

As will be noticed from the diagram, tensile specimens were prepared from both upper corners of the head and from both flanges. In rolling, the side that receives the brand is down and the heat number is stamped on the side that is up, and this side gets the water that is used for cooling the rolls and falls on the rail. Samples a and f are from the bottom side of the rail, from the head and flange, respectively, and samples b and g are similar samples from the top side. The results of the longitudinal tensile tests are shown in the following table:

Rail.	Location.	Yield Point lbs. per sq. in.	Tensile Str. lbs. per sq.in.	Ratio.	Elong. per cent. in 2 in.	Reduction of area per cent.
A	a—head, cor.	.....	111,000	..	5	6
		62,460	100,600	62	3.5	3
	b—head, cor.	72,600	111,500	65	6	6
		64,500	95,770	67	3	2
	c—head, int.	.....	......	..	2.5	1
		74,530	94,500	79	1.5	2
	d—web	76,820	113,000	68	2	2
		73,310	116,300	63	3	3
	e—base	81,670	85,080	96	2	1
		65,820	98,270	67	2.5	2
	f—flange	66,330	111,900	59	5.5	5
		65,720	117,600	56	16	24
	g—flange	65,060	113,400	57	16	28
		65,520	115,800	57	13	15
B	a—head, cor.	66,940	122,900	54	15	27
		67,250	123,300	54	16	28
	b—head, cor.	68,400	123,200	55	13	21
		67,500	110,500	61	4	4
	c—head, int.	68,370	128,300	53	12.5	20
		63,430	126,700	50	14.5	22
	d—web	72,240	127,400	57	5	6
		71,020	128,400	55	10	10
	e—base	66,740	107,320	62	2.5	3
		65,310	125,300	52	6	6

Rail.	Location.	Yield Point lbs. per sq. in.	Tensile Str. lbs. per sq.in.	Ratio.	Elong. per cent. in 2 in.	Reduction of area per cent.
	f—flange	71,430	122,780	58	5.5	5
		72,350	125,170	58	15.5	27
	g—flange	73,210	124,800	59	6.5	6
		72,310	124,300	58	9.5	9
C	a—head, cor.	67,900	122,700	56	14	26
		67,760	122,100	55	15.5	27
	b—head, cor.	66,740	122,400	55	14.5	26
		66,540	122,400	54	16	27
	c—head, int.	63,180	122,620	52	12.5	19
		61,340	119,980	51	15	23
	d—web	66,740	123,290	54	15.5	27
		66,640	121,240	55	16	28
	e—base	64,910	122,880	53	12	18
		63,500	122,280	52	15	25
	f—flange	69,800	123,490	57	15	28
		68,980	123,540	56	15.5	26
	g—flange	72,040	124,300	58	15.5	28
		70,110	124,600	56	16	28
D	a—head, cor.	66,380	123,280	54	15	28
		65,970	121,900	54	16	28
	b—head, cor.	68,110	123,440	55	15	29
		67,860	122,260	56	16	27
	c—head, int.	61,540	117,010	53	15.5	28
		59,910	114,720	52	16.5	30
	d—web	67,760	118,290	57	16	31
		67,040	115,790	58	18	34
	e—base	64,190	122,000	53	11.5	15
		63,580	120,010	53	16	26
	f—flange	70,810	124,330	57	14	27
		69,180	124,500	55	15.5	26
	g—flange	69,690	125,100	56	15	26
		70,450	124,300	57	15	26

In the above results it will be noted that the specimens from the A rail shows very low ductility except three of the four specimens from the flange, which showed about normal ductility. The B rail shows very much more ductility, but even here five or six of the fourteen samples showed considerably less stretch than normal for their tensile strength, the normal stretch being about 13 or 14 per cent. for a tensile strength of 125,000 lbs. All the samples from the C and D rails showed fair ductility.

The ratio of the yield point to the tensile strength is shown in the following tabulation, in which I have neglected all cases where the stretch was low and the rail broke short.

Location.	A rail.	B rail.	C rail.	D rail.	Av.
a—head, cor.		54 %	55.5%	54 %	54.5%
b—head, cor.		55	54.5	55.5	55.0
c—head, int.		51.5	51.5	52.5	51.8
d—web		55	54.5	57.5	55.8
e—base		...	52.5	53	52.8
f—flange	56	58	56.5	56	56.8
g—flange	57	58	57	57.5	57.5

It is interesting to note that the lowest ratio occurs in the samples from the interior of the head with an average of 51.8 per cent., next in the samples from the base with 52.8 per cent., then from the corner of the head, then the web, and the highest ratio from the flanges, averaging 57.2 per cent. This seems to run along with the difference in finishing temperature, the lowest ratio being from the part with the highest finishing temperature. The flange of the side on top in rolling, i. e., the g location, seems also to have a little higher ratio than the bottom flange.

A comparison of the tensile strengths is interesting, and I give below a table showing the tensile results, showing the tensile strength of the sample in each pair that gave the greatest ductility.

Location.	A Rail.	B Rail.	C Rail.	D Rail.	Average B, C & D.
a—head, cor.	......	123,300	122,100	121,900	122,430
b—head, cor.	......	123,200	122,400	122,260	122,620
c—head, int.	......	126,700	119,980	114,720	120,470
d—web	......	128,400	121,240	115,790	121,800
e—base	......	125,300	122,280	120,010	122,530
f—flange	117,600	125,170	123,540	124,500	124,400
g—flange	113,400	124,300	124,600	125,100	124,670

Most of the samples from the A rail broke "short" before their normal tensile strength was developed, and I have omitted these from the above table, showing only results from the two flanges. The c sample from the interior of the head and the d sample from the web represent what was the interior of the ingot, and it will be noted that their strength decreases as we go down the ingot. Unfortunately a comparison cannot be made in the A rail, but in the B rail their strength shows a little above the samples representing the outer part of the ingot. In the C rail their strength is a little below the other samples, and in the D rail, considerably so. In other words, the upper part of the ingot has a hard center and the lower part of the ingot a soft center by comparison with the outer part of the section.

Another interesting feature is shown by the flanges of the A rail. The flange samples in the other rails show a fairly uniform strength, averaging 124,500 lbs. per sq. in., while in the A rail the f sample gave 117,600 lbs. and the g sample 113,400 lbs. We have already seen that the chemical analyses show a little negative segregation of phosphorus and sulphur, and although the analysis did not show a similar result as regards carbon, the tensile results indicate strongly that there probably was also some reduction of carbon in the outer part of the section at the top end of the A rail.

The a and b samples from the head and the f and g samples from the flange would all be of similar chemistry, as representing the outer part of the ingot, but the flange has a lower finishing temperature and is also reduced differently, and I give below tables comparing the results from these places.

TENSILE STRENGTH.

Rail.	a	b	f	g
A—	......	......	117,600	113,400
B—	123,300	123,200	125,170	124,300
C—	122,100	122,400	123,540	124,600
D—	121,900	122,260	124,500	125,100
Av. B, C & D	122,430	122,620	124,400	124,670

Yield Point.

Rail.	a	b	f	g
A—	......	......	65,720	65,060
B—	67,250	68,400	72,350	72,310
C—	67,760	66,540	68,980	70,110
D—	65,970	67,860	69,180	69,690
Av. B, C & D	66,990	67,600	70,170	70,700

	Per Cent. Elongation.				Per Cent. Reduction.			
Rail.	a	b	f	g	a	b	f	g
A—	..	..	16	16	..	..	24	28
B—	16	13	15.5	9.5	28	21	27	9
C—	15.5	16	15.5	16	27	27	26	28
D—	16	16	15.5	15	28	27	26	26
Av. B, C & D	15.8	15.0	15.5	13.5	27.7	25	26.3	21

Comparing the a sample from the side of the head which was underneath in rolling with the b sample from the top side, the two locations give results very much alike. Sample f from the bottom flange and sample g from the top flange also give results very much like each other. It would seem, therefore, that the water that gets on the side of the rail on top in rolling produces no important difference between the two sides in the tensile properties.

Comparing the upper corner of the head with the flange, it will be noted that the flange gave an average of almost 3,000 lbs. higher yield point and about 2,000 lbs. higher tensile strength. The ductility was about the same, if we omit from this comparison the g sample from the B rail, which seems to have given abnormally low stretch and reduction. There is a suggestion here that the lower finishing temperature of the flange and quicker cooling after finishing, as well as difference in reduction, may have had the effect of raising the yield point and tensile strength a little, but the difference is not decisive, and it may even be due to a slight difference in the chemistry of the two locations.

The c sample from the interior of the head and the d sample from the web would be of similar chemistry as representing the interior of the ingot, but the web is thinner and gets more work in rolling, and probably is finished at a lower temperature. A comparison of these two locations is shown in the following table:

	Tensile Strength, lbs. per sq. in.		Elongation, per cent. in 2 in.		Reduction of area—per cent.	
Rail.	c	d	c	d	c	d
A—	......	......	1.5	3	2	3
B—	126,700	128,400	14.5	10	22	10
C—	119,980	121,240	15	16	23	28
D—	114,720	115,790	16.5	18	30	34
Av. B, C & D	120,470	121,810	15.3	14.7	25	24

The samples from the interior of the head and from the web of the A rail had low ductility, as shown by the small stretch and reduction, and they broke "short." Considering the other rails, the tensile strength decreases as we go down the ingot and the ductility increases. Allowing for the difference in tensile strength, the samples from the head show about the same ductility in the B, C and D rails, but of the web samples the one from the B rail shows less ductility than those from the C and D rails. Comparing the two locations, there is but little difference in their tensile properties, although the web seems to show a slight tendency toward a higher strength and a slightly greater ductility, if we neglect the web sample from the B rail.

Tests were made of samples taken transversely through the middle of the head, as shown on the diagram, with results as shown in the following table:

Rail.	Yield Point, lbs. per sq. in.	Tensile Str. lbs. per sq. in.	Elongation. per cent. in 1 in.	Reduction of area—per cent.
A—	.....	79,760	1	.6
	.....	81,000	1	.8
B—	72,040	99,340	3	2.0
	72,100	97,040	2	2.0
C—	71,480	.....	3	3.6
	75,880	.....	5	4.0
D—	70,080	.....	3	2.4
	71,070	95,350	3	2.0

These samples all showed low ductility and all broke "short," giving a low tensile strength. The most stretch and reduction were given by the samples from the C rail. All the samples showed a small seam across the fracture and running lengthwise of the rail. The yield point, however, shows up just as high transversely as longitudinally, as shown in the following table, comparing the transverse results with the longitudinal results from the interior of the head.

Rail.	Transverse.	Longitudinal.
A—	......	......
	......	74,530
B—	72,040	68,370
	72,100	63,430
C—	71,480	63,180
	75,880	61,340
D—	70,080	61,540
	71,070	59,910

The yield point runs higher in the transverse specimens, but this is undoubtedly due largely to the difference in the method of determining the yield point in the two classes of specimens.

DROP TESTS.

Two drop tests were made of each rail, one with the head in tension and the other with the base in tension, with results as shown in the table, Fig. 6, which shows the deflections of the rails, the elongations of the metal on the side in tension and diagrams of the fractures. The tup was 2,000 lbs., height of drop 18 ft., supports 3 ft. apart, and the anvil was the standard spring-supported anvil of 10 tons. The deflection as measured includes the depression caused by the die of the tup. The temperature of the air and rail was about 80°.

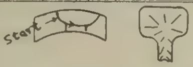
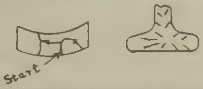
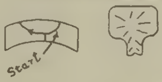
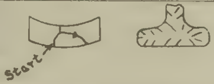
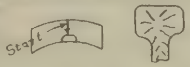
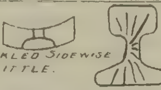
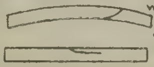
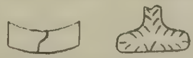
TEST NUMBER	HEAD OR BASE IN TENSION	HEIGHT OF DROP	NUMBER OF BLOW	DEFLECTION	1 MARKS AFTER BLOW 1/100THS						REMARKS
					1	2	3	4	5	6	
ET1A2	H	18	1	BROKE	1.00	1.01	—	1.01	1.01	100	
ET1A3	B.	18	1	BROKE	1.02	1.02	—	1.02	101	101	
ET1B2	H	18	1	BROKE	104	1.06	106	106	—	104	
ET1B3	B	18	1	154	1.04	1.05	106	106	1.05	104	
			2	2.85	1.07	110	1.11	1.11	1.09	107	
			3	BROKE	1.08	1.10	—	112	109	1.07	
ET1C2	H	18	1	163	105	107	1.09	109	107	105	
			2	303	110	114	116	115	112	1.08	
			3	BROKE	110	114	—	—	112	108	
ET1C3	B	18	1	164	1.05	1.06	1.06	1.06	105	104	 BUCKLED SIDEWISE A LITTLE.
			2	298	1.08	1.10	1.11	1.12	1.10	108	
			3	4.30	1.09	1.14	1.16	1.16	1.14	1.11	
			4	BROKE	—	1.15	1.17	1.17	1.15	—	
ET1D2	H.	18	1	1.69	1.05	1.07	1.09	1.09	1.07	1.05	BASE CRACKED FOR ABOUT 6" ON 2ND BLOW EXTENDING FROM ONE SIDE WHERE STRUCK  THIS EVIDENTLY CAUSED BREAK ON NEXT BLOW
			2	3.10	114	1.17	1.16	1.12	1.08	1.06	
			3	BROKE	1.14	1.18	1.18	1.13	1.08	1.06	
ET1D3	B.	18	1	1.65	—	1.05	1.06	1.06	1.06	1.04	 WEB SHOWS A FEW SMALL LAMINATIONS
			2	2.99	—	1.10	112	1.11	1.10	1.07	
			3	BROKE				1.13	1.11	1.08	

FIG. 6.

The deflection after the first blow and the maximum elongation after the first blow, of the metal in tension, are compared in the following table:

	Elongation—1st blow.		Deflection—1st blow.	
Rail.	Head Tension.	Base Tension.	Head Tension.	Base. Tension.
A	1% broke	2% broke	broke	broke
B	6% broke	6%	broke	1.54 in.
C	9%	6%	1.63 in.	1.64 in.
D	9%	6%	1.69 in.	1.65

It will be noted that the deflection was approximately the same with either the head or base in tension, but the maximum stretch of the metal was 50 per cent. greater with the head in tension. The A rail broke on the first blow, both with the head in tension and with the base in tension, and the B rail also broke on the first blow with the head in tension, so the deflection could not be determined, but the deflection seems to increase as we go down the ingot.

I give below a table showing the elongations obtained under successive blows when the rail did not break as a result of the blow:

	Elongation—Head Tension.		Elongation—Base Tension.		
Rail.	1st blow.	2d blow.	1st blow.	2d blow.	3d blow.
A	..	..	..	..	..
B	..	..	6%	11%	..
C	9%	16%	6	12	16
D	9	17	6	12	..

This table is useful in calculating from the elongation which the metal gave at fracture, the approximate height of blow which would be just sufficient to cause fracture, and will be so used below.

The number of blows which broke the rails and the maximum elongations obtained when broken are shown in the following table:

	Maximum Elongation.		No. of blows.	
Rail.	Head Tension.	Base Tension.	Head Tension.	Base Tension.
A	1%	2%	1	1
B	6	12	1	3
C	14	17	3	4
D	18	13	3	3

With head tension the stretch of the metal increases as we go down the ingot, the variation being from 1 per cent. stretch in the

A rail to 18 per cent. stretch in the D rail. With base tension the result is somewhat similar, but the difference is not so great and the maximum stretch was obtained in the C rail. The variation was from 2 per cent. stretch in the A rail to 17 per cent. in the C rail.

I give below a table showing the approximate height which would be just sufficient to cause fracture. This is determined by taking the elongation at the last blow which did not cause fracture and figuring that each per cent. elongation beyond this with head in tension was due to 2.0 ft. drop and each per cent. increase with base in tension was due to 3.0 ft. drop.

Rail.	Head Tension.	Base Tension.
A	2 ft.	6 ft.
B	12	43
C	40	63
D	44	46

A study of the fracture diagrams shows that with the head in tension, the fracture started from a point near the middle of the head. With the base in tension, in the C rail, the fracture started in the web, due evidently to some sidewise buckling. In the A and B rails the break started near the middle of the base, while in the D rail it seems to have started near the bottom of the base.

BENDING TESTS.

Two pieces, each 4½ ft. long, were cut from each rail for bending in the test machine, one with the head in tension and the other with the base in tension, using a span of 3 ft. The supports were flat surfaces 1 in. wide, whose edges were 3 ft. apart. To get the deflections, a beam was made of ⅜ by 3 in. flat iron, bent so as to rest on the top of the rail at places 3 ft. apart and to suspend about 3 in. below the middle of rail. The distance between the bottom of the rail and the beam was measured at each increment of load by means of calipers and a scale reading to hundredths of an inch. This method was an effort to include in the reading of the deflection only the actual bending of the rail, although I did not accomplish this in an entirely satisfactory manner. The rails were bent to destruction and the breaking load determined. They had previously been stamped with gauge marks 1 in. apart for a space of 6 in. on the side in tension, and the stretch determined after breaking.

The deflections obtained are shown in the following table, the heading, "Hd." or "B," designating the part in tension, head or base,

	ET1 A		ET1 B		ET1 C		ET1 D	
Load.	Hd.	B.	Hd.	B.	Hd.	B.	Hd.	B.
40,000	.04	.03	.05	.03	.04	.02	.03	.03
80,000	.09	..	.10	.08	.09	.07	.08	.08
90,000	.11	.10	.11	.09	.11	.08	.09	.10
100,000	.13	.10	.12	.11	.12	.11	.11	.11
110,000	.15	.12	.14	.13	.16	.12	.13	.13
120,000	.19	.14	.18	.15	.20	.15	.18	.17
130,000	.26	.19	.24	.18	.27	.19	.26	.23
140,000	.36	.30	.34	.28	.36	.29	.37	.36
150,000	..	.39	.40	.38	.49	.41	.52	.50
160,000	..	.52	.52	.50	.63	.55	.68	.65
170,000	..	..	.65	.64	.77	.71	.89	.84
180,000	..	..	.84	.70	1.04	.93	1.13	1.05
190,000	..	..	1.08	1.02	1.34	1.16	1.36	1.26
200,000	..	..	..	1.29	1.79	1.44	1.80	1.57
210,000	..	..	..	1.59	..	1.83	..	2.00
220,000	..	..	..	..	..	2.43	..	2.59

The load-deflection curves plotted from these tables are shown as Fig. 7, and it will be noted that the rails are a little stiffer with the base in tension than with the head in tension, although the difference is not great. The elastic limit with the head in tension seems to be about 120,000 lbs. for the A and B rails and about 5,000 lbs. less for the C and D rails. With the base in tension it seems to be about 130,000 lbs. for the A, B and C rails and 120,000 lbs. for the D rail, as shown on the diagram. These figures, however, can be taken only as rough approximations.

The loads which the rails broke at and the maximum elongations of the metal in tension are shown in the following table:

	Breaking Load.		Elongation.	
Rail.	Head Tension.	Base Tension.	Head Tension.	Base Tension.
A	150,000	169,200	2%	2%
B	198,800	218,400	5	10
C	203,500	221,800	11	11
D	202,600	221,000	11	11

It will be noted that the A rail broke at a considerably less load than the other rails, and also the metal in this rail gave very little stretch, both with head tension and with base tension.

A comparison of the elongations in slow bending and in the drop test is shown in the following table:

	Head Tension		Base Tension	
Rail.	Drop.	Slow Bending.	Drop.	Slow Bending.
A	1%	2%	2%	2%
B	6	5	12	10
C	14	11	17	11
D	18	11	13	11
Average	13	9.7	14.7	11.3

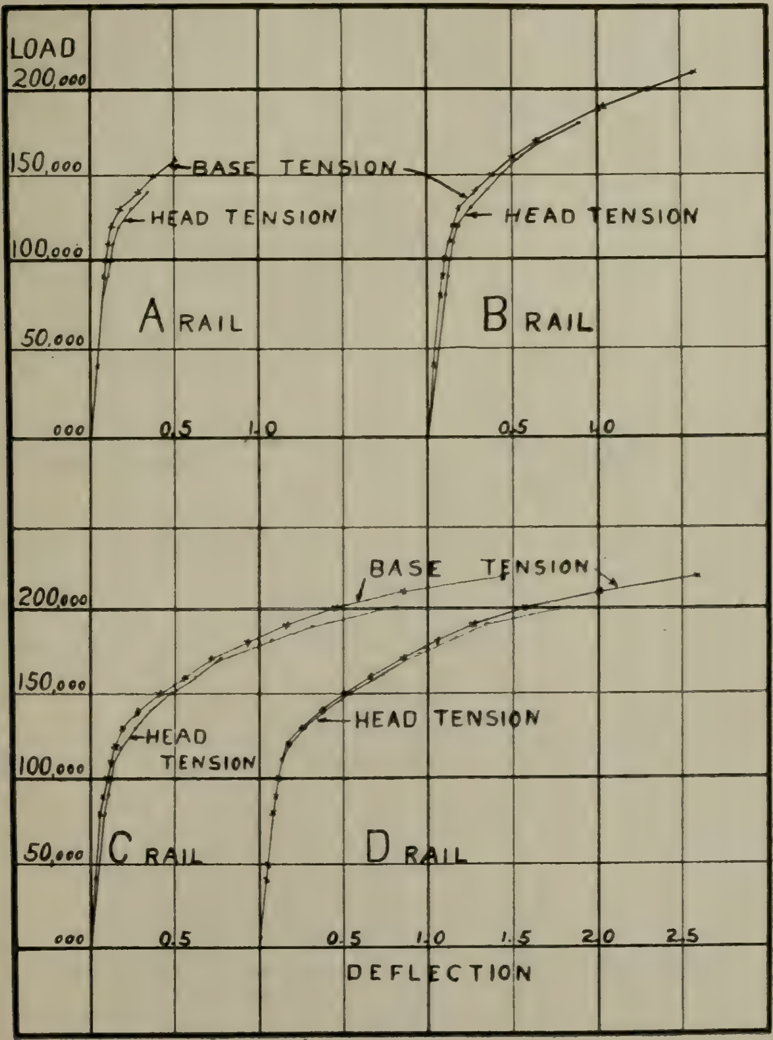


FIG. 7.

It appears from this that the metal stretched more in the drop test than in the slow bending tests.

Diagrams of the fractures are shown in Fig. 8. It will be noted from these, that, with the head in tension, the break started near the middle of the head. With the base in tension, the break started within the base.

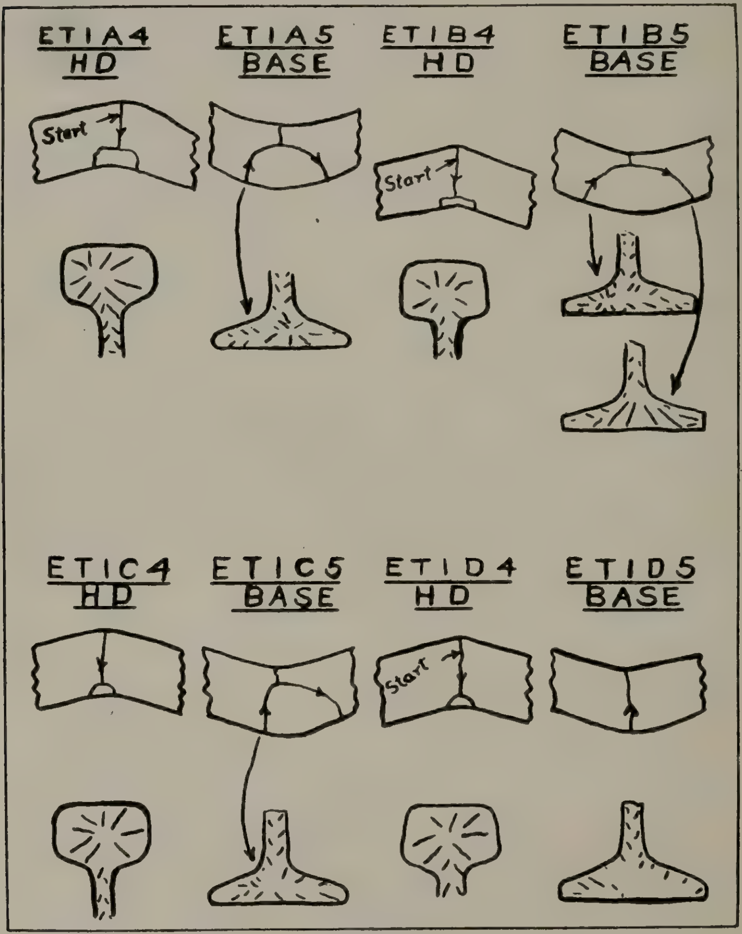


Fig. 8.

Finally, I wish to acknowledge the very courteous treatment and considerable help I received from the officers of the Steel Company, who furnished all the facilities for these tests.

INVESTIGATION OF A SPLIT HEAD RAIL

By M. H. Wickhorst, Engineer of Tests, Rail Committee.

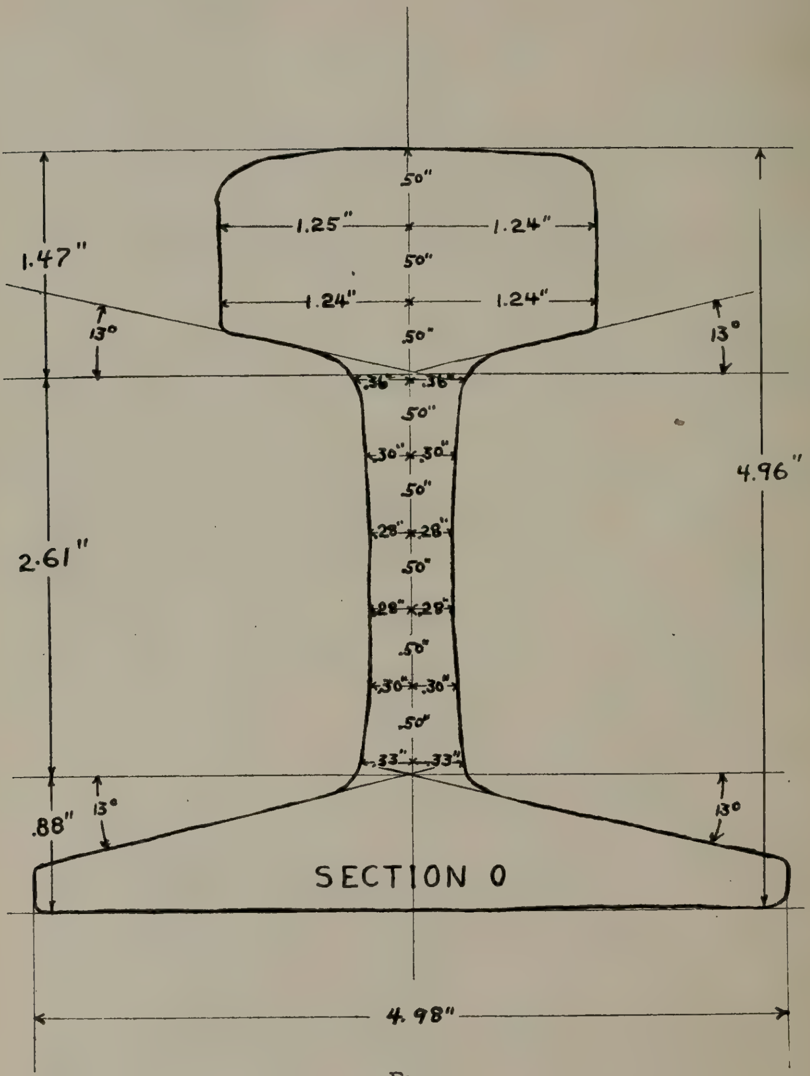
This report covers a study and tests of a very interesting and instructive rail that failed due to a split head, and is intended to throw some light on the cause of failure. This rail was one of a number that failed in a somewhat similar manner in a lot of 80-lb. A. S. C. E. rails laid in about October, 1909, by the Wabash R. R. on straight track in its main line near Adrian, Mich. It was a 33-ft. Bessemer rail, made at the Edgar Thomson Works at Braddock, Pa., of the Carnegie Steel Company, in September, 1909, heat number 11508. It was removed from service in May, 1910. The rail had no letter showing its position in the ingot. The total tonnage over this rail was about 4.3 million freight tons and the passenger trains additional. The heaviest engines that ran on this rail weighed 103 tons, with a maximum weight of 14 tons per driving wheel. The bearing on the ties as shown by the rust marks on the bottom of the rail averaged 7½ inches and the tie spacing as determined by measuring from center to center of the rust marks was as follows:

1 ft. 5 in.
3 ft. 0 in.
4 ft. 10 in.
6 ft. 6 in.
8 ft. 2 in.
9 ft. 8 in.
10 ft. 11 in.
12 ft. 11 in.
14 ft. 9 in.
16 ft. 4 in.
17 ft. 10 in.
19 ft. 10 in.
21 ft. 9 in.
23 ft. 8 in.
25 ft. 4 in.
27 ft. 3 in.
29 ft. 3 in.
30 ft. 4 in.
32 ft. 6 in.

A diagram of the section at its good end showing the measurements of the various dimensions is given as Fig. 1.

The examination consisted of etchings with copper potassium chloride of a large number of transverse and horizontal longitudinal sections cut from the rail, chemical analyses, tensile tests of specimens cut from the rail and microscopic examination.

Report No. 7, September, 1910.


.50"
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.50"
.30"
.30"
.50"
.28"
.28"
.50"
.28"
.28"
.50"
.30"
.30"
.50"
.33"
.33"
4.96"
2.61"
.88"
13°
13°
SECTION 0
4.98"

FIG. 1.

ETCHINGS.

As stated, sections were cut from the rail at a number of places and etched with copper potassium chloride. These are shown as Figs. 2 to 21, inclusive, and represent distances from one end of the rail as follows:

0 ft.
2
8
14
17
18
18 ft. 1 in.
18 ft. 6 in.
19
20
22
23
24
25
26 ft.
27
28
30
31
32

The left side of the pictures represents the gage side of the rail and was the side on top in rolling.

It will be noted that for a distance of 17 ft. from the end, the rail shows no crack in the interior of the head, but shows a well-defined "core." The section at 18 ft. shows a crack inside the head, on the right side, which is larger at 18 ft. 1 in. and at 18 ft. 6 in. extends through almost the full depth of the head. It is also seen to angle over to the middle of the head. At 23 ft. the section contains two cracks, the new and smaller crack being on the left side. At 25 ft. the second crack disappears and the section shows only the one crack. At 26 ft. the section again shows two cracks, both being fully developed and extending through almost the full depth of the head. The two cracks continue through to the section at 32 ft. All the sections show a well-defined "core."

Etchings were also made of polished horizontal longitudinal sections of the head of the rail taken from 18 ft. 2 in. to 23 ft. and from 30 ft. 3 in. to 33 ft. The top of the head was planed off to half its depth, or a thickness of ⅝-in., near the side. The polished surfaces, etched with copper-potassium chloride, are shown in Fig. 22. The gaps in the picture represent the portions cut out for the etchings of the transverse sections. It will be noticed that the crack which starts at about 18 ft. on the right side angles over so that in about 18 inches it is on the left side, and this crack evidently continues through to the end of the rail more or less to the left of the center. The other crack, which occurs in section 23, is seen to start at about 28 ft. 8 in., and the transverse sections show it to run out in about 2 ft. The third crack, which is first met in section 26, on the right side, is shown by the transverse and longitudinal sections to run continuously to 32 ft. 1 in.

A prominent feature of the longitudinal etchings is the dark interior portion or core and the longitudinal streaks.

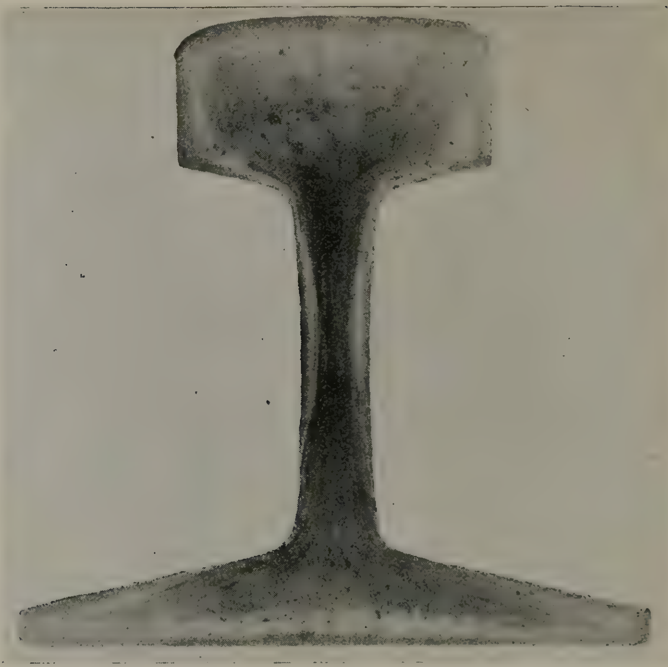

FIG. 2. SECTION 0 FT.

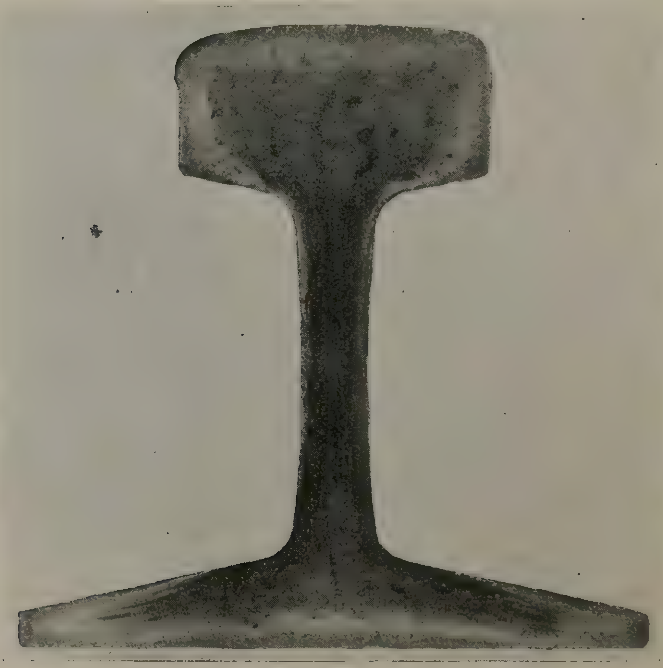

FIG. 3. SECTION 2 FT.

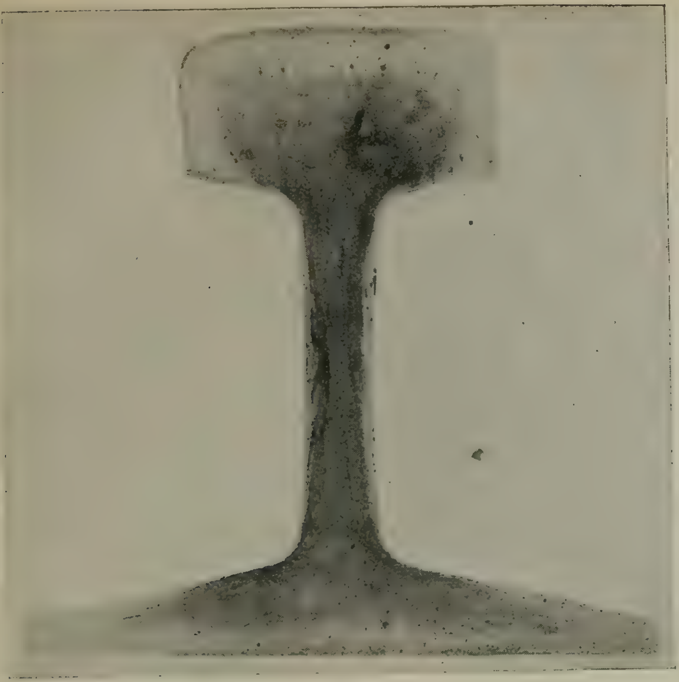

FIG. 4. SECTION 8 FT.

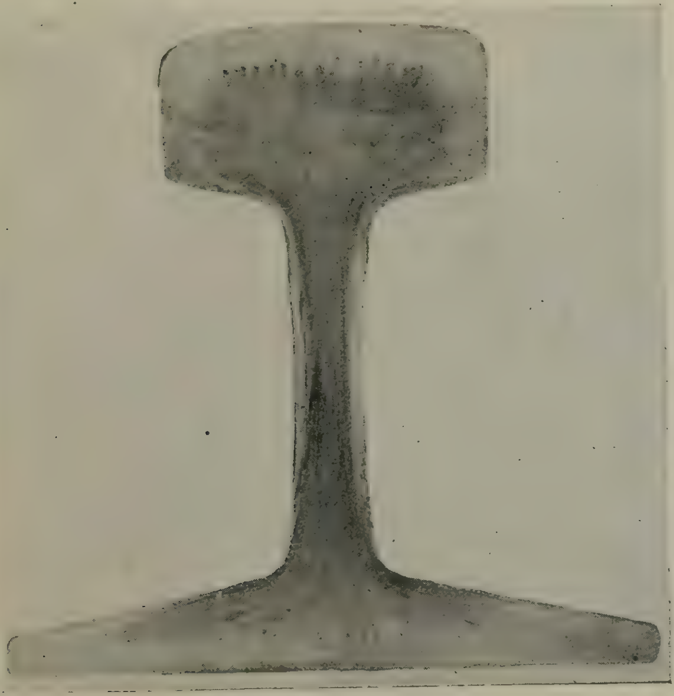

FIG. 5. SECTION 14 FT.

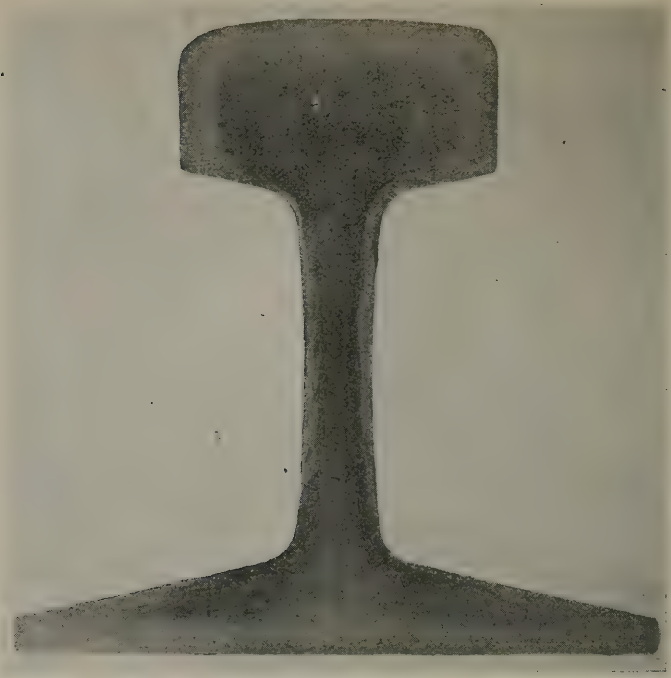

FIG. 6. SECTION 17 FT.

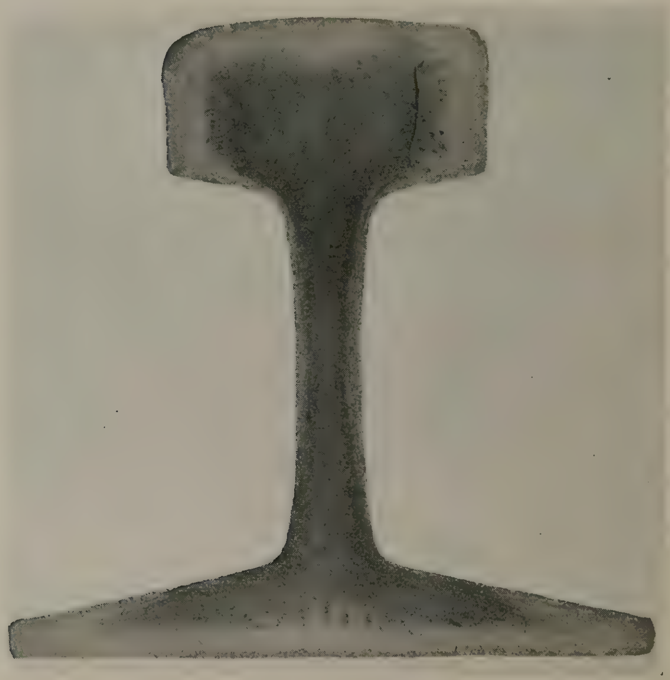

FIG. 7. SECTION 18 FT.

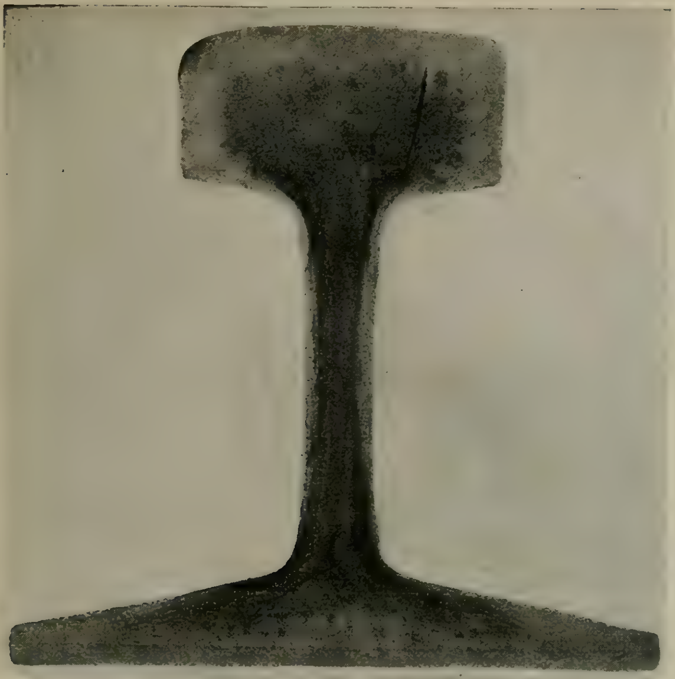

FIG. 8. SECTION 18 FT. 1 IN.

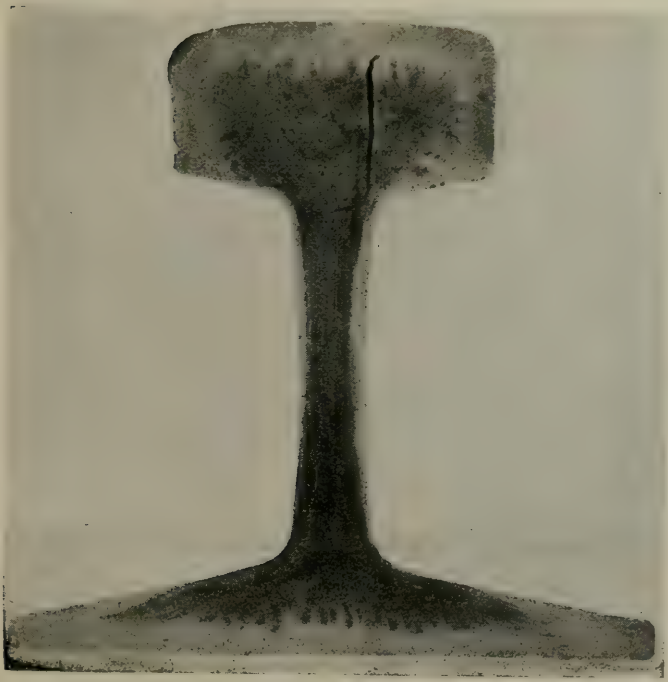

FIG. 9. SECTION 18 FT. 6 IN.

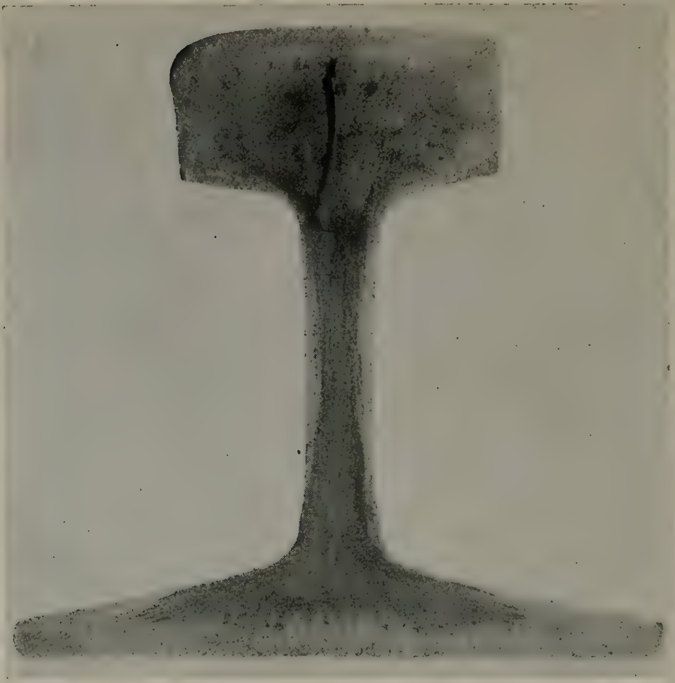

FIG. 10. SECTION 19 FT.

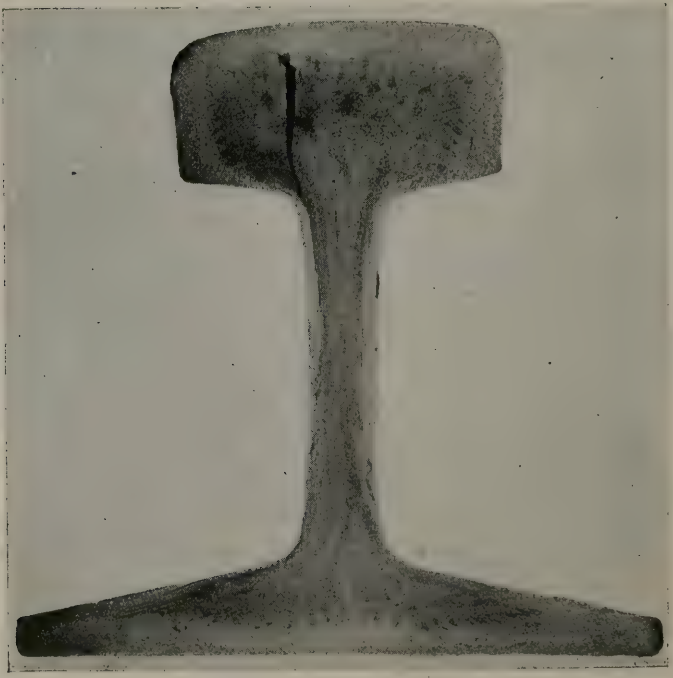

FIG. 11. SECTION 20 FT.

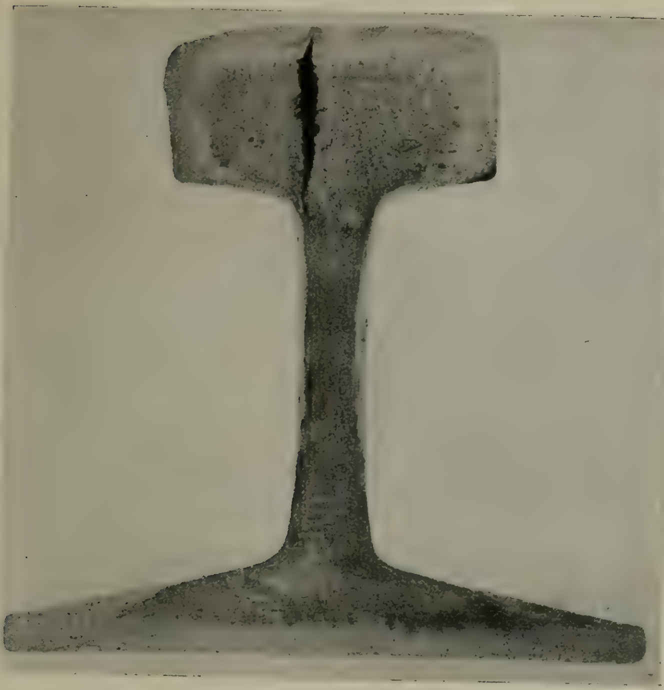

FIG. 12. SECTION 22 FT.

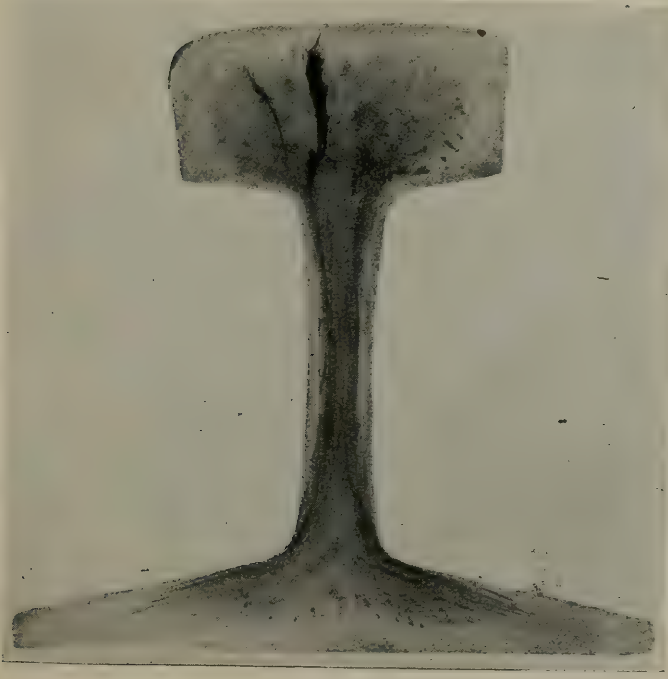

FIG. 13. SECTION 23 FT.

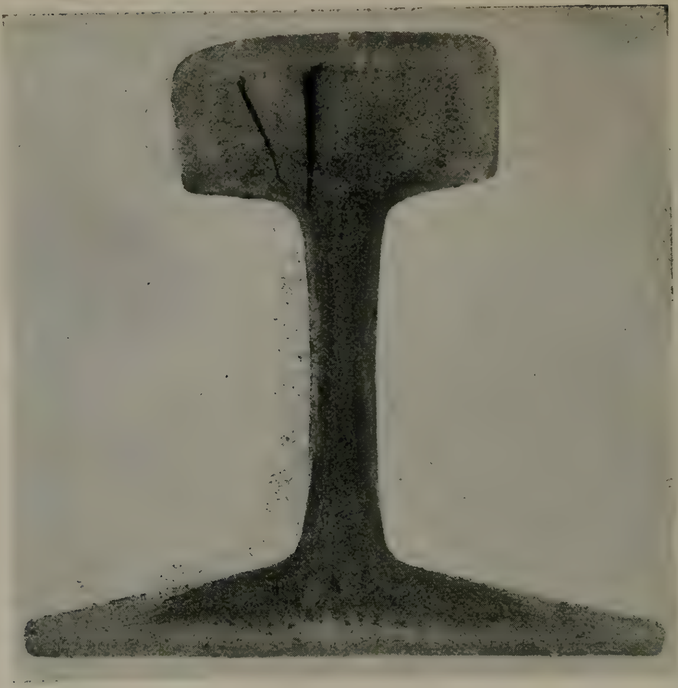

FIG. 14. SECTION 29 FT.

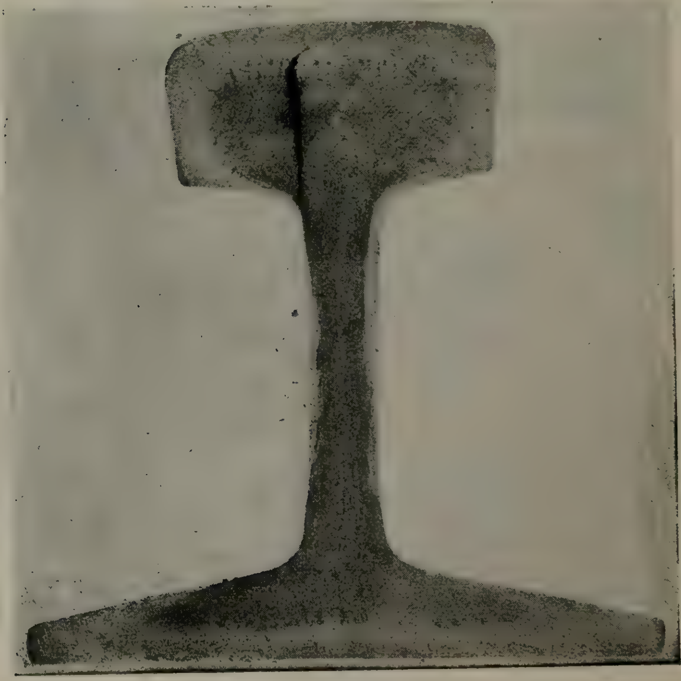

FIG. 15. SECTION 25 FT.

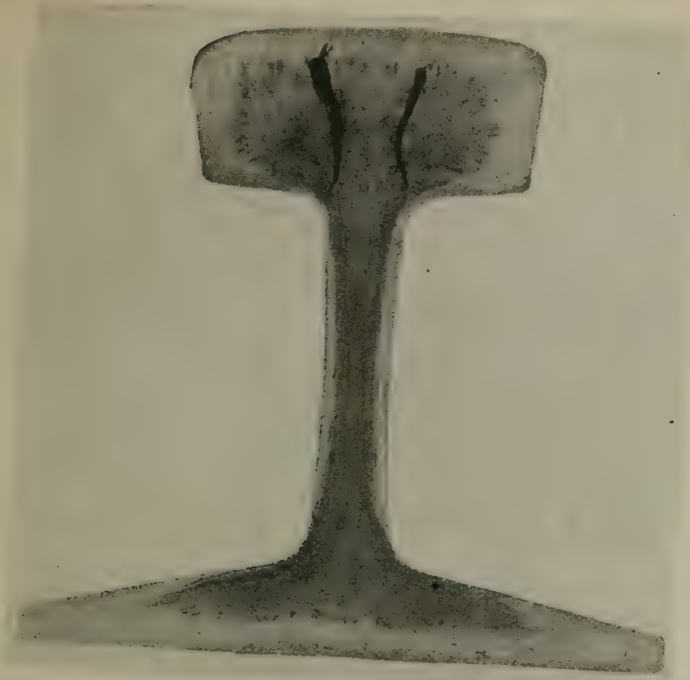

FIG. 16. SECTION 26 FT.

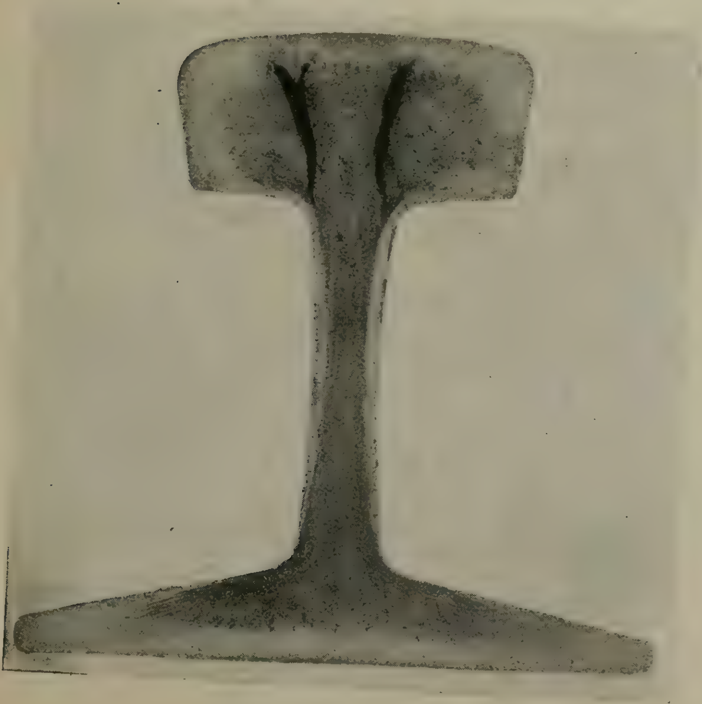

FIG. 17. SECTION 27 FT.

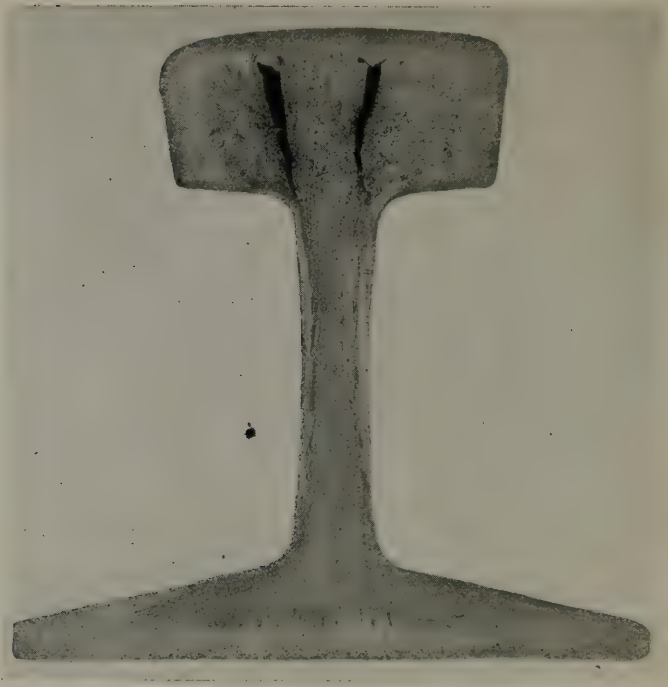

FIG. 18. SECTION 28 FT.

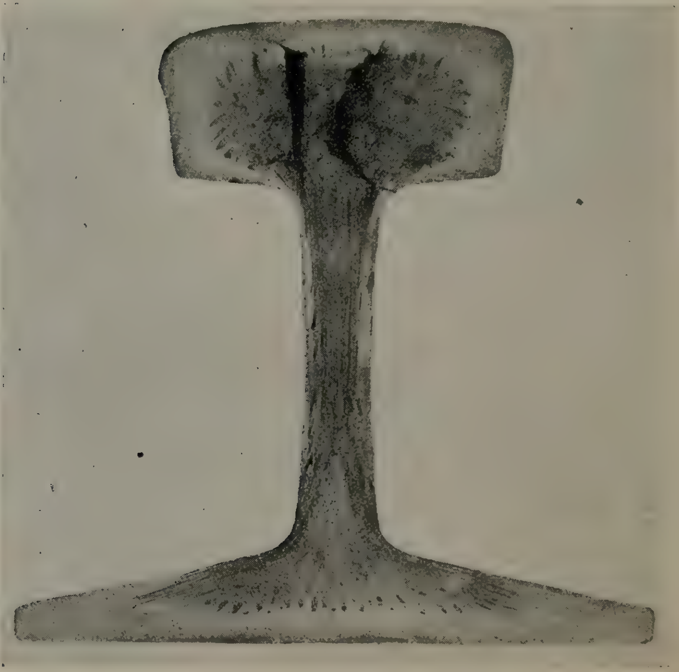

FIG. 19. SECTION 30 FT.

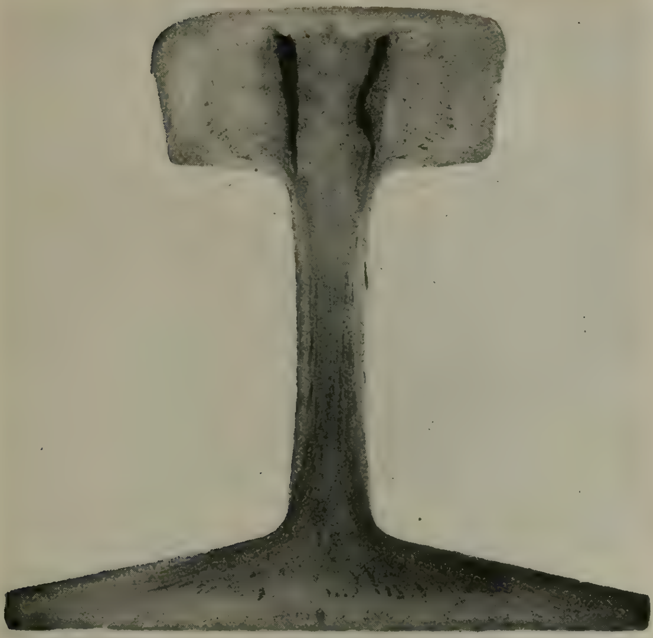

Fig. 20. Section 31 Ft.

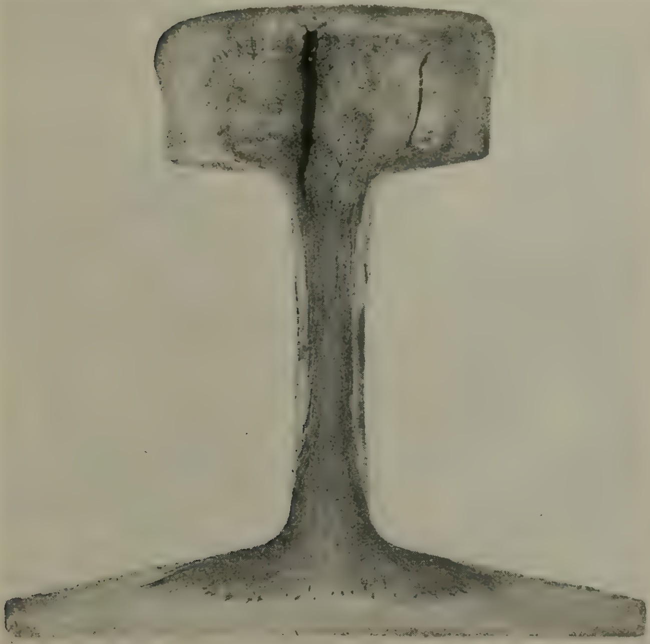

Fig. 21. Section 32 Ft.

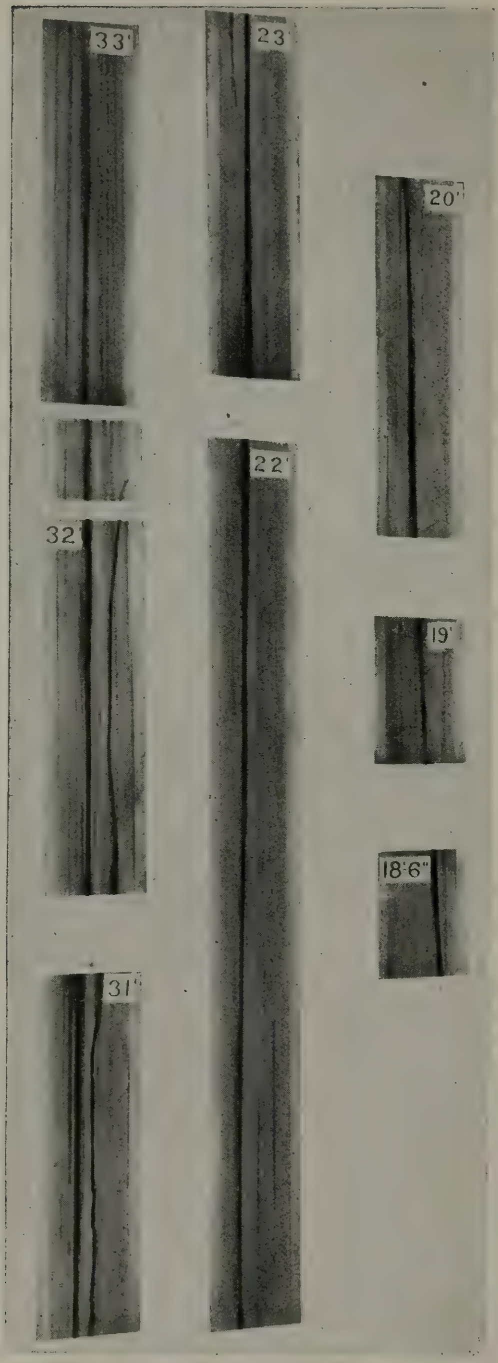

FIG. 22. HORIZONTAL LONGITUDINAL SECTIONS OF RAIL HEAD, ETCHED WITH COPPER-POTASSIUM CHLORIDE.

CHEMICAL ANALYSES.

Analyses were made of three samples taken from section 17 which showed no crack on etching, and of three samples from section 26, which showed two large cracks in the head. The samples were taken with a ¼-in. drill, as shown in Figs. 23 and 24, and consisted of one sample from the head just below the top surface, to represent the head metal or "envelope" around the "core," a second sample parallel with the top surface, but just inside the core, and a third sample from the interior of the web. The results of the analyses are shown in the following table:

	Section 17.			Section 26.		
	Top of head.	Core.	Web.	Top of head.	Core.	Web.
Carbon	.43	.83	.86	.43	.83	.85
Phosphorus	.069	.144	.172	.055	.138	.149
Sulphur	.027	.073	.071	.022	.056	.051
Manganese	.82	.90	.93	.82	.91	.92
Silicon	.09	.11	.12	.11	.11	.09

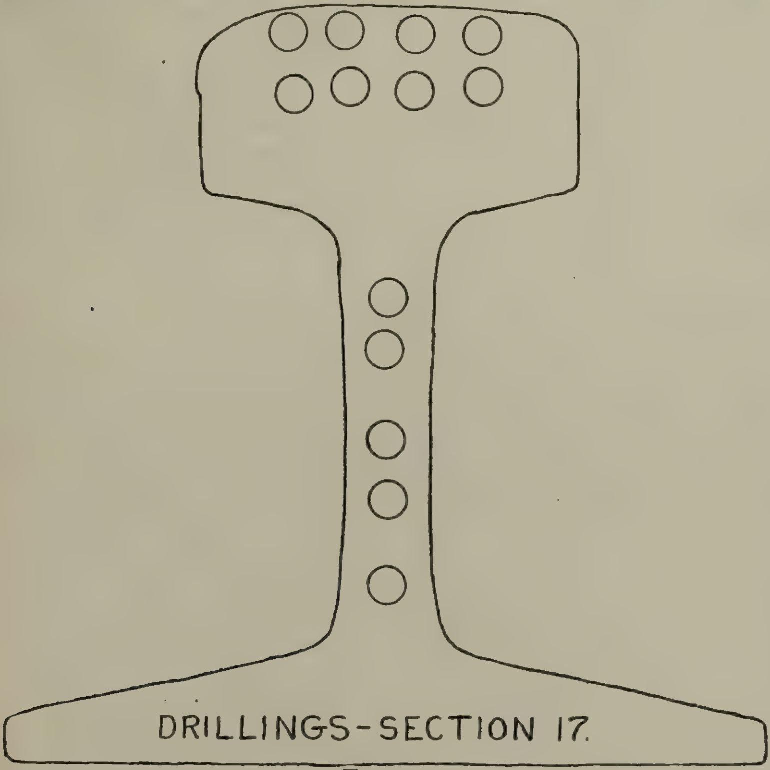

FIG. 23.

For convenient comparison I give below the chemical composition recommended by the Rail Committee in supplement to Bulletin 121, dated March, 1910, for 80-lb. Bessemer rail:

Carbon	.40 to .50
Manganese	.80 to 1.10
Silicon	.07 to .20
Phosphorus, not to exceed	.10
Sulphur, not to exceed	.075

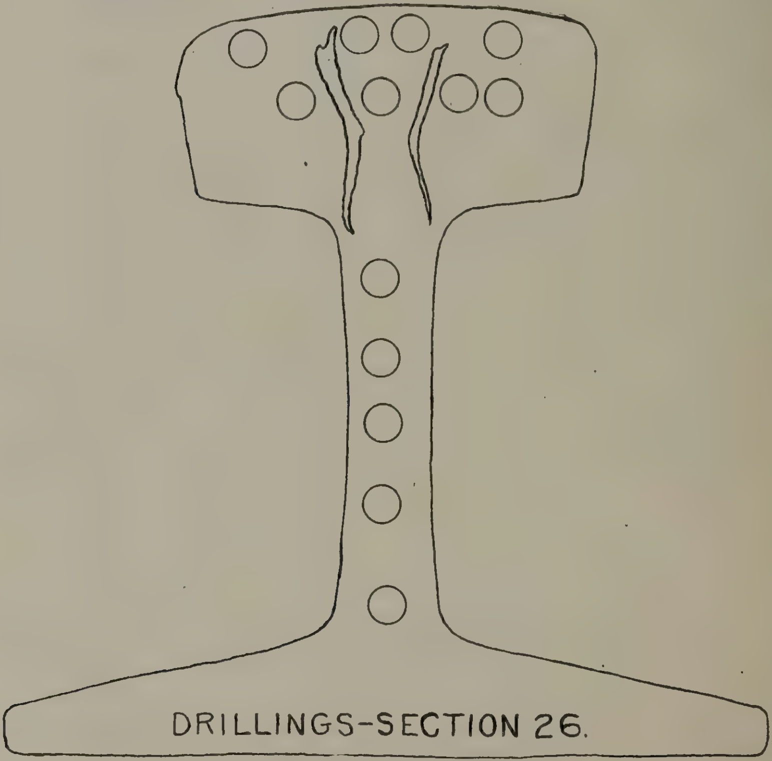

FIG. 24.

The metal from the "core," it will be noted, shows very considerable segregation of carbon, phosphorus and sulphur, and a little segregation of manganese, but apparently no segregation of silicon The metal contained no copper.

The amount of excess of carbon, phosphorus and sulphur in the "core" as compared with the metal directly above it in the "envelope" is shown below, expressed in per cent.:

	Section 17.	Section 26.
Carbon	93%	93%
Phosphorus	109	151
Sulphur	170	155
Manganese	10	11

The carbon and phosphorus in the core are both very high and such metal would be very brittle and could have but little ductility. The phosphorus and sulphur in the outer metal, or "envelope," are considerably below normal for Bessemer steel as made at the Edgar Thomson Works, and this suggests that considerable negative segregation has occurred here.

The etchings and analyses indicate strongly that this rail was from the upper part of the ingot, although, as stated above, the rail had no letter stamped on it to show its ingot position.

TENSILE TESTS.

Longitudinal and transverse specimens were cut from the rail for tensile tests, as shown in Figs. 25 and 26, at a distance of about 16 ft. from the end, and for each location, two test specimens were prepared, so that the tests were made in duplicate. Specimens f and g from the flange were cut with their centers 1½ in. from the side instead of ⅞-in., as shown in the diagram, on account of the flange being too thin to allow getting the full diameter of ½-in. at a distance of ⅞-in. from the side. The longitudinal specimens were ½-in. diameter by 2 in. gauge length, and the transverse specimens were the same diameter, with a gauge length of 1 in. Transverse specimens were cut from the base also, although not shown in Fig. 26. The results of the tensile tests are shown in table below. Eight of the eighteen specimens broke outside of the gauge marks, namely, a1, c1, d1, d2, f1, f2, h1 and h2. The yield point was determined by means of a Capp's multiplying dividers, except in the transverse specimens with a 1-in. gauge length, where the drop of the beam was taken as the yield point.

Location.	Yield Point. lbs. per sq. in.	Tensile Str. lbs. per sq. in.	Elongation.	Reduction of area.
a1—head, cor.	......	84,500	3 %	2.3%
2—head, cor.	55.590	76,900	2	2.3
b1—head, cor.	69,020	103,400	8	10.5
2—head, cor.	63,760	97,990	5	3.8
c1—head, int.	70,820	92,060	5	0.0
2—head, int.	69,450	79,630	1	0.7
d1—web	67,460	104,380	2.5	2.3
2—web	68,890	109,080	3	2.7
e1—base	73,820	136,320	5	5.5
2—base	72,390	128,350	4	4.7

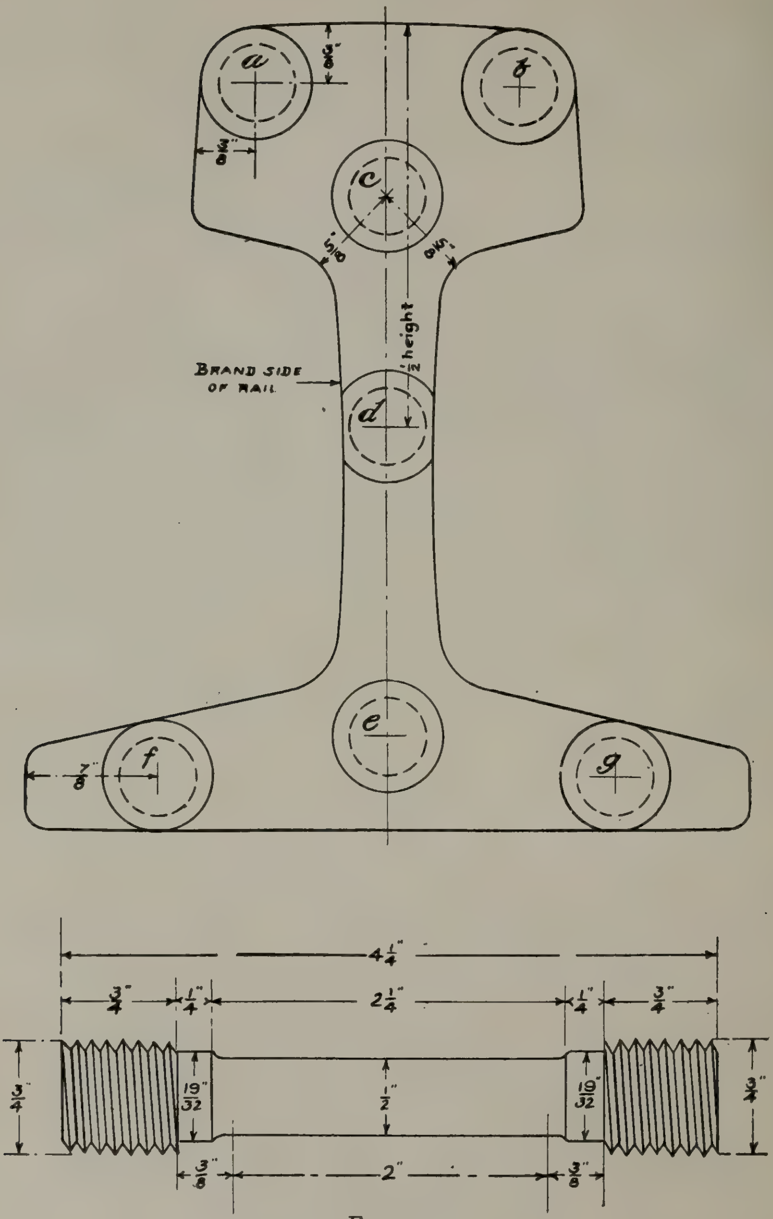
a
3/8"
3/8"
b
c
5/8"
5/8"
½ height
BRAND SIDE OF RAIL
d
e
7/8"
f
g
4¼"
3/4"
1/4"
2¼"
1/4"
3/4"
3/4"
19/32"
1/2"
19/32"
3/4"
3/8"
2"
3/8"

FIG. 25.

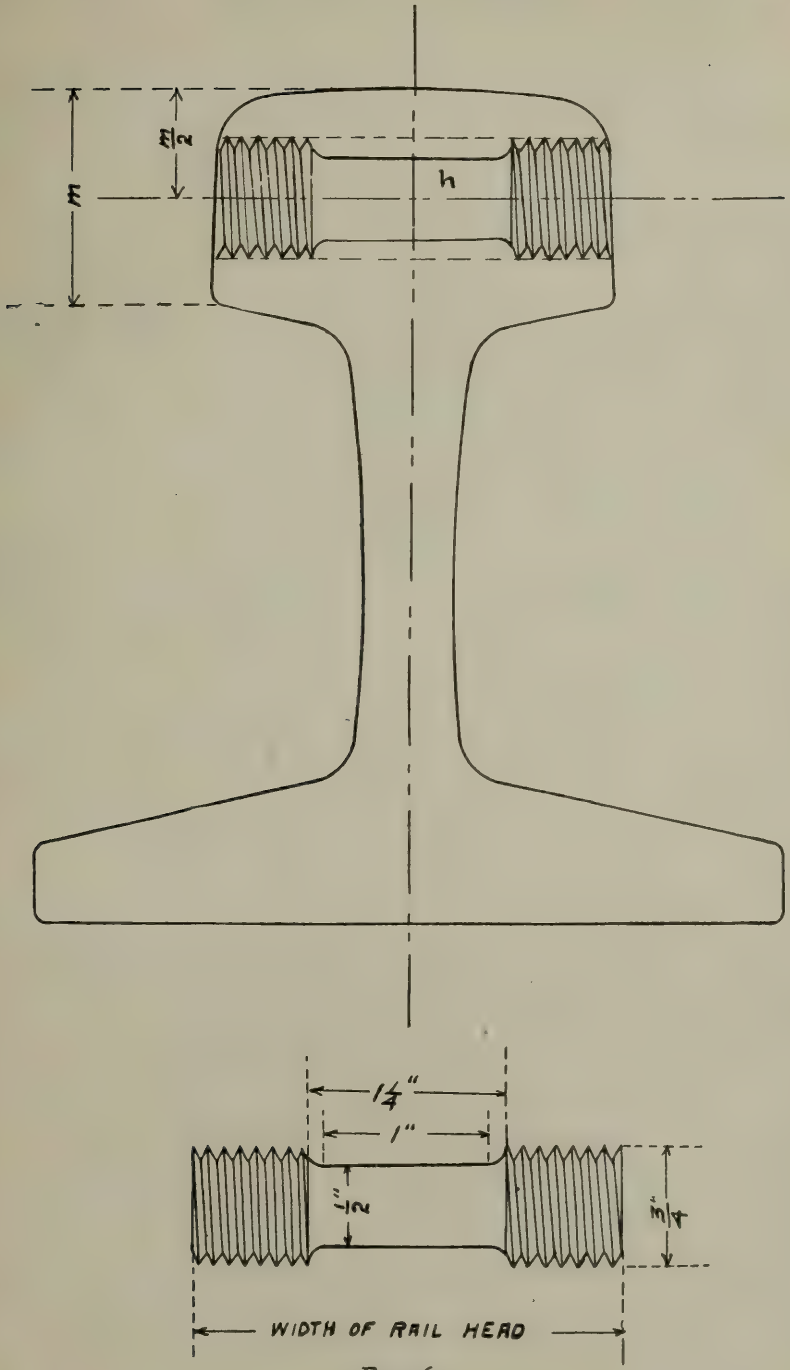

Fig. 26.

Location.	Yield Point. lbs. per sq. in.	Tensile Str. lbs. per sq. in.	Elongation.	Reduction of area.
f1—flange	60,940	100,420	2%	3.1%
2—flange	58,530	110,680	8.5	9.7
g1—flange	62,730	114,590	12	14.3
2—flange	55,230	90,870	3	2.7
h1—head, trans.	.....	75,470	0	0
2—head, trans.	.....	75,880	0	0
i1—base, trans.	63,400	77,420	1	1.5
2—base, trans.	60,830	88,400	2	2.7

The most noticeable feature of these results is the very low ductility of almost all of the specimens, only three samples showing more than 5 per cent. elongation, namely, b1 from the corner of the head, with 8 per cent. elongation, f2 from the flange, with 8½ per cent., and g1 from the flange, with 12 per cent., and of these the latter is the only one that at all approaches the normal ductility for this grade of steel. The specimens all had threaded ends and the holders had ball joints, but still, as stated above, eight specimens broke outside of the gauge marks. On account of the low ductility most of the specimens broke "short" before the full tensile strength normal to the steel was developed. The yield point, however, seems in all cases to have been about normal to the composition of the specimen. The transverse specimens from the head broke at but little above the yield point, with no elongation and no reduction of area. The fractures also both showed streaks running lengthwise of the rail, which seemed to be a small crack in the head, and not unlikely were the beginning of a split head. The transverse specimens from the base showed in their fractures a small seam running lengthwise of the rail. The fractures of the longitudinal specimens from the web showed in their middle portions areas of finer crystalline structure, corresponding to the core as developed by the etching.

MICROSCOPIC TESTS.

Microscopic examination was made of a vertical transverse section of the rail and of a vertical longitudinal section of the head of the rail. These were examined, both after plain polishing and also after polishing and etching with picric acid solution in alcohol. The plain polished surfaces showed a great many small pits, due apparently to the breaking out of a brittle material during the polishing. The polished surface of section 26, in the core near one of the cracks, magnified 40 diameters, is shown in Fig. 27 and the polished surface of a vertical longitudinal section of the interior of the head of the rail

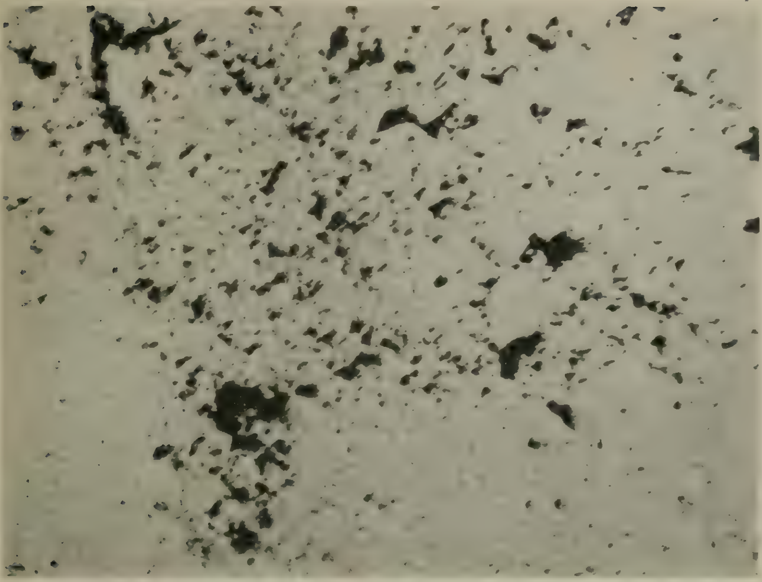

FIG. 27. TRANSVERSE SECTION, POLISHED AND MAGNIFIED 40 DIAMETERS.

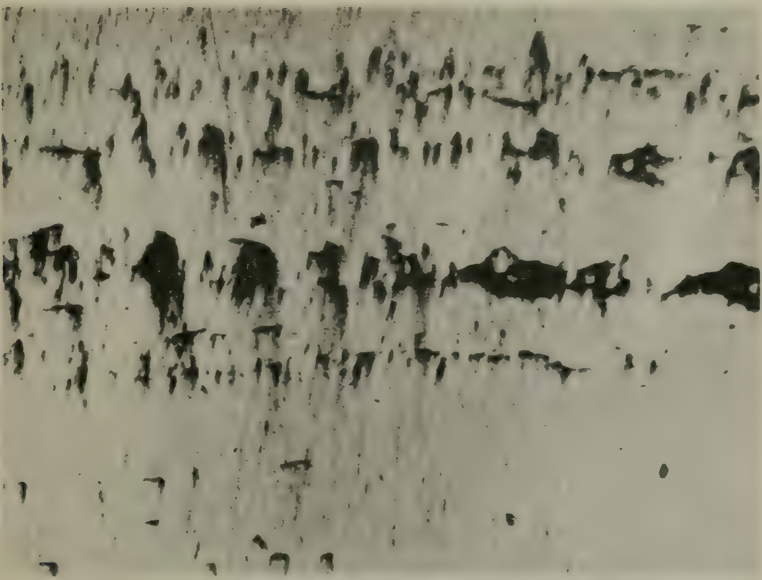

FIG. 28. VERTICAL LONGITUDINAL SECTION, POLISHED AND MAGNIFIED 40 DIAMETERS.

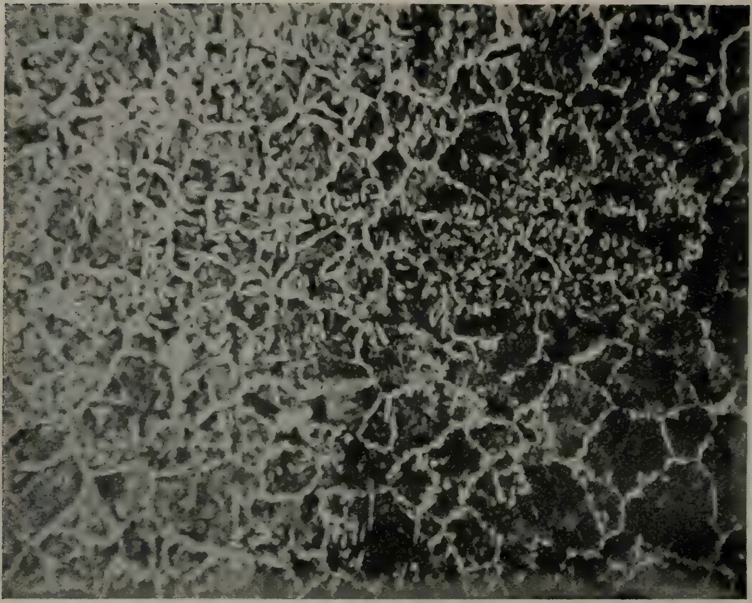

Fig. 29. Transverse Vertical Section, "Envelope" Etched with Picric Acid and Magnified 40 Diameters.

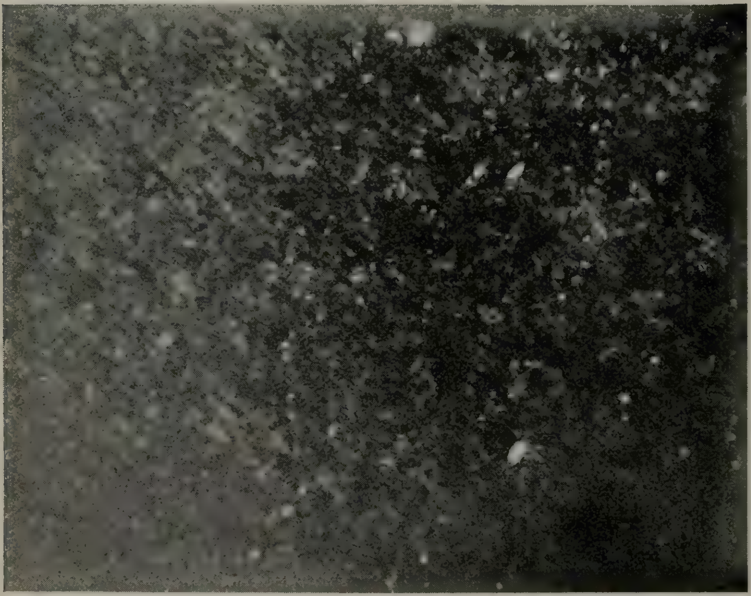

Fig. 30. Transverse Vertical Section, "Core" Etched with Picric Acid and Magnified 40 Diameters.

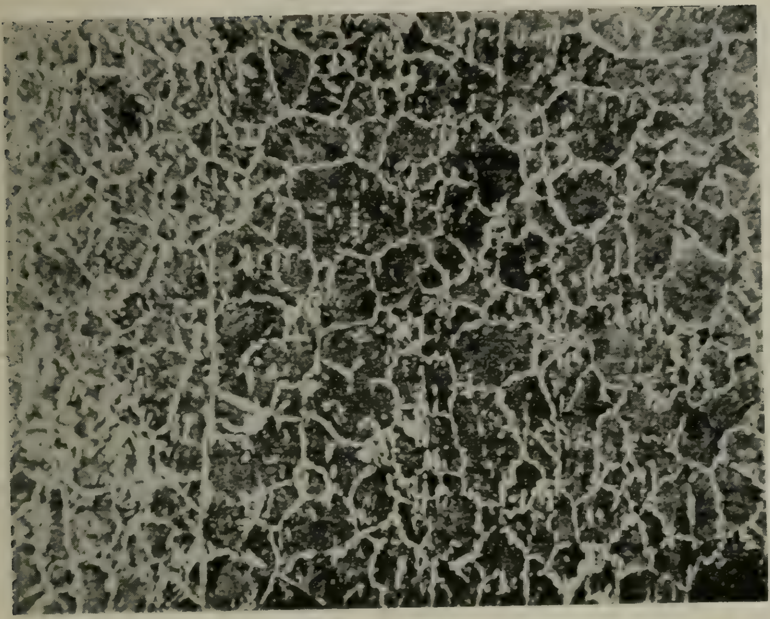

Fig. 31. Longitudinal Vertical Section, "Envelope" Etched with Picric Acid and Magnified 40 Diameters.

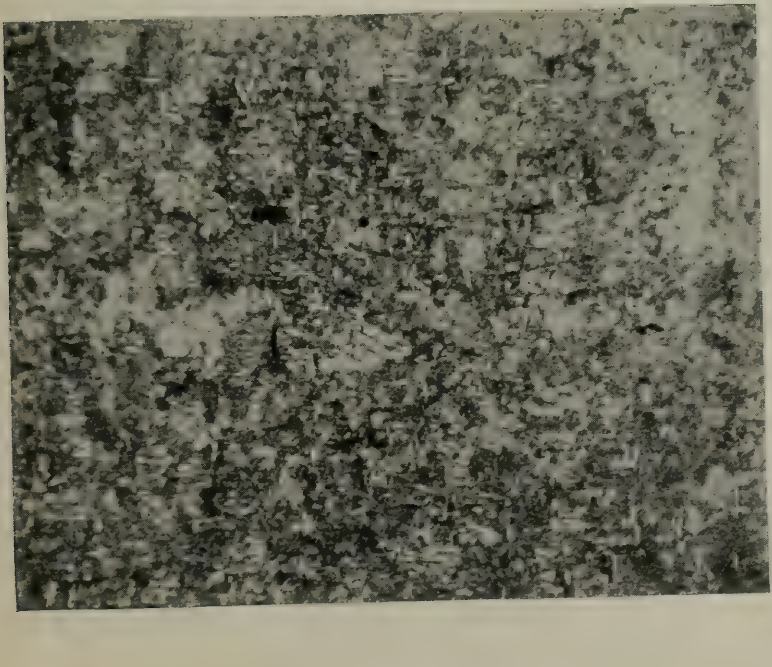

Fig. 32. Longitudinal Vertical Section, "Core" Etched with Picric Acid and Magnified 40 Diameters.

magnified 40 diameters is shown in Fig. 28. The pits are shown as dark spots and in the longitudinal section are seen to occur in streaks running lengthwise of the rail. Fig. 29 shows a transverse vertical section at the upper part of the head etched with picric acid and magnified 40 diameters. Fig. 30 shows the same surface down in the core. Figs. 31 and 32 are similar to Figs. 29 and 30, respectively, but represent longitudinal vertical sections instead of transverse. The etched surfaces of the envelope show the white network of ferrite normal to steel of about .4 per cent. carbon, and at the surface the amount of ferrite is very large, but the core does not show the net of ferrite, which also is normal to steel with about .8 per cent. carbon.

The pits in the plain polished surfaces must be due, it would seem, to some brittle material breaking out, as, for instance, enclosure of slag or any non-metallic material, or segregrate of carbon or phosphorus compounds. The etched surfaces seem to show no indication of slag, and in the plain polished surfaces the pits are seen to be very angular, which would suggest that they were not due to enclosed slag. This suggests then that the pits contained some brittle metallic compound, although it must be said that the matter is left in a decidedly speculative condition.

DEVELOPMENT OF CRACK.

A rail in service tends to widen at the upper part of the head, that is, the upper part of the head extends transversely. The amount of widening varies considerably with different rails, some showing but little and others a large amount. The compressive effect of the rolling wheels evidently causes the metal to flow transversely, and this flowing seems always to be greatest at about the top of the rail. The metal at the top of a rail is practically always ductile material, but the metal in the interior of the head may sometimes be brittle and incapable of transverse extension, and in such a case, when the top flows and widens, the interior metal, as it cannot stretch likewise, must develop a crack. Of course, anything which takes away the ductility of the metal in the head in a transverse direction would allow of the formation and development of cracks, as, for instance, slag enclosures, seams and laminations, due to gas holes and pipes, or bad segregation. In the case in hand the splitting of the head seems to have been due to bad segregation of the carbon and phosphorus. *The metal seems to have been good metal in the ladle, but it evidently went to the bad in the making of the ingot,* although the dangerous segregation could, indeed, have been removed with a sufficient discard from the top. This suggests that it would be desirable to make a somewhat comprehensive study of such matters as size and shape of ingot and other conditions influencing segregation.

After a crack has opened up, the metal above it, of course, tends to flow into it under the action of the wheel loads, and after this metal has reached the limit of its ductility in compression, it shears along diagonal lines, resulting in the "wedge" generally seen above a crack. The crack generally comes to the surface at the underside of the head at its junction with the web, although occasionally it runs down into the web and comes to the surface at the side of the web.

In conclusion, I wish to say the thanks of the Committee are due for this interesting and valuable study to Mr. F. A. Delano, President, and Mr. G. G. Yeomans, Assistant to the President, of the Wabash Railroad, who furnished the facilities of their shops for the machine work required to prepare the various sections and test pieces, to Mr. H. E. Byram, Vice-President of the C., B. & Q. R. R., who offered the facilities of the laboratory of that road, and to Mr. W. A. Derby, Engineer of Tests, and Mr. A. Bridge, Metallographist, of the C., B. & Q. R. R., for the considerable interest they took in the laboratory work.

SEGREGATION AS INFLUENCED BY FIRE-CLAY ON INGOT.

By

M. H. Wickhorst, Engineer of Tests—Rail Committee.

This report covers tests made to investigate the effect on segregation of putting fire-clay on the ingot directly after pouring. During the regular pouring of a heat of Bessemer steel of six ingots, two of the ingots were selected for test, one of which was without any covering, and the other of which was covered directly after pouring with a half-shovelful of fire-clay, equal to about two pounds. They were made at the Edgar Thomson Works of the Carnegie Steel Co. at Braddock, Pa., on August 9, 1910, heat 5,101. Mixer metal and scrap steel were blown and poured into the teeming ladle, liquid spiegel being poured in at the same time. The metal was then poured at once into the molds, without any other addition. The ingots were 18½x19½ at the bottom. The stools and molds had been sprayed with a wash of fire-clay. The metal set quietly in both ingots. The uncovered ingot hardened quickly on top, while the covered ingot remained liquid on top for some time.

After being in the soaking pit for about 1 hr. 40 min., the ingots were bloomed to 9½x9½ inches, and instead of making the usual discard from the top, as little as practicable was sheared off. The usual practice at this mill is to cut the bloom into two billets, making the large discard from the top and a small one from the bottom. Each of these billets makes two rails. In the present case, as stated, only a small amount was sheared from the top, and the rails from the top billet were reserved for this investigation, which happened to be 90-lb. A. R. A. type B section. Previous to rolling into rails, the billets were run through a reheating furnace. The weights of the ingots and amounts discarded from the top, including both the bloom and rail croppings, were as follows:

Ingot Test No..............,	ET4	ET5
Top covering................	None	Fire-clay
Weight, total................	5,356 lbs.	5,346 lbs.
Cut from top................	193 "	228 "
Per cent. from top...........	3.6 per cent.	4.3 per cent.

The top discards, it will be noted, were equivalent to rail lengths of about 6½ and 7½ ft., respectively.

The investigation consisted of drop tests, chemical analyses and etchings of sections. The A and B rails of each ingot were divided into units

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Report No. 8, October, 1910.

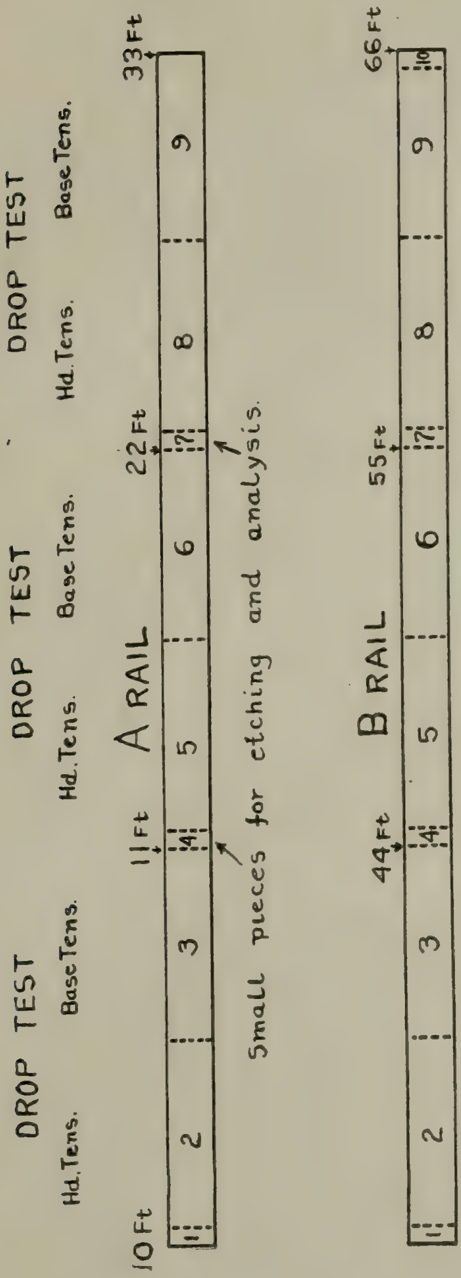


Fig. 1—Diagram of Tests Made.

of a third of a rail length each, or 11 ft., and each of the tests made on each unit. The pieces cut from each rail and the tests made of them are shown in the following list:

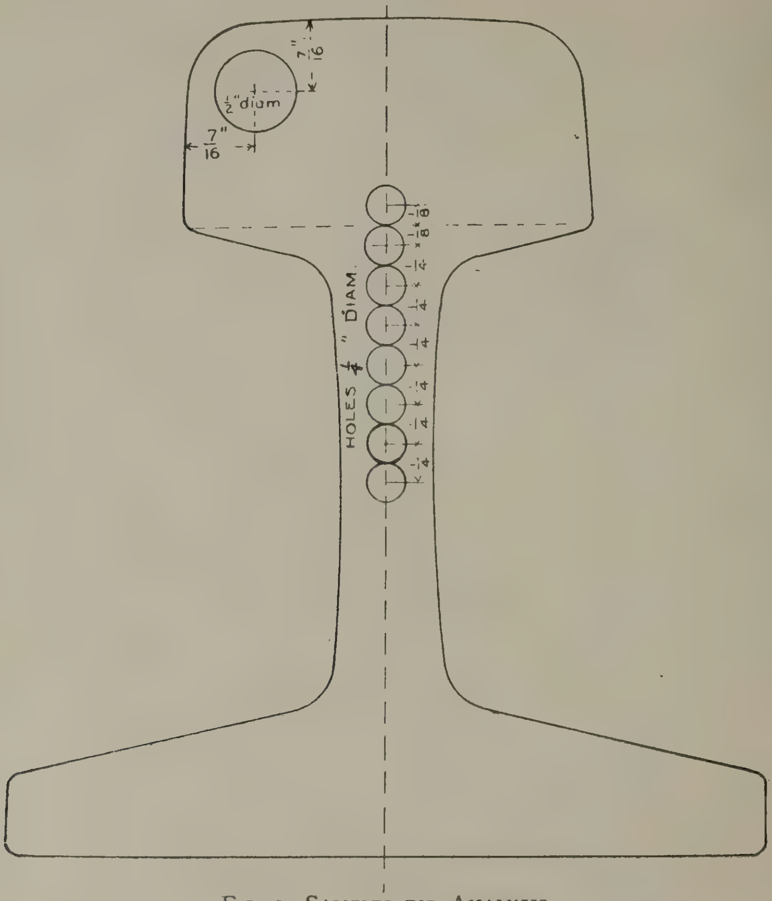


Fig. 2—Samples for Analysis.

Piece No.	Test.
1	Analyses and etching.
2	Drop test, head tension.
3	Drop test, base tension.
4	Analyses and etching.
5	Drop test, head tension.
6	Drop test, base tension.
7	Analyses and etching.
8	Drop test, head tension.
9	Drop test, base tension.
10	Analyses and etching (B rail only).

This information is also shown diagrammatically in Fig. 1.

ANALYSES.

Analyses were made at intervals of 11 ft. along the rails, and two samples were taken from each section, one from near the upper corner of the head and the other from the web, as shown in Fig. 2. Ladle samples were taken at the end of the pouring of each ingot. The analyses of these various samples and the average results on the head samples of the B rail are shown in table No. 1. The average of the samples from the corner of the head of the B rail is taken as probably representing as near as can be determined the average steel as poured into the mold. Due to failure of the steel to mix thoroughly in the ladle, a small sample taken while pouring, as in the ladle test, may not always be a true average.

TABLE I—CHEMICAL ANALYSIS.

Distance	Carbon.		Phosphorus.		Sulphur.		Manganese.		Silicon.	
from top.	Pln.	Cvd.	Pln.	Cvd.	Pln.	Cvd.	Pln.	Cvd.	Pln.	Cvd.
0—Head	.43	.43	.080	.082	.045	.047	1.02	1.01	.112	.107
Web	.46	.55	.085	.116	.045	.070	1.11	1.14	.140	.140
11—Head	.49	.49	.081	.094	.050	.058	1.07	1.09	.112	.115
Web	.54	.63	.130	.163	.078	.094	1.14	1.18	.112	.135
22—Head	.51	.52	.092	.097	.060	.058	1.08	1.04	.115	.115
Web	.55	.61	.136	.128	.086	.077	1.14	1.15	.103	.121
33—Head	.51	.53	.095	.097	.055	.058	1.08	1.10	.112	.121
Web	.49	.42	.118	1.04	.067	.060	1.13	1.10	.112	.121
44—Head	.52	.47	.096	.096	.065	.060	1.10	1.11	.107	.121
Web	.42	.49	.105	.100	.061	.057	1.10	1.14	.112	.103
55—Head	.50	.45	.097	.097	.060	.065	1.06	1.10	.112	.121
Web	.46	.54	.102	.095	.058	.056	1.08	1.10	.103	.112
66—Head	.48	.46	.098	.099	.053	.060	1.06	1.09	.107	.117
Web	.43	.52	.100	.097	.054	.053	1.08	1.07	.112	.093
Av. head samples, B rail	.50	.48	.097	.097	.058	.061	1.08	1.10	.110	.120
Ladle test:										
ET4	.43		.096		.064		1.06		.121	
ET5	.49		.100		.055		1.04		.112	

In the above table the carbon, phosphorus and sulphur show considerable segregation in some of the web samples, while the manganese and silicon show a fairly even distribution.

For more convenient study, the phosphorus results are plotted in diagrams Fig. 3. The distance in feet that the sample was taken from the

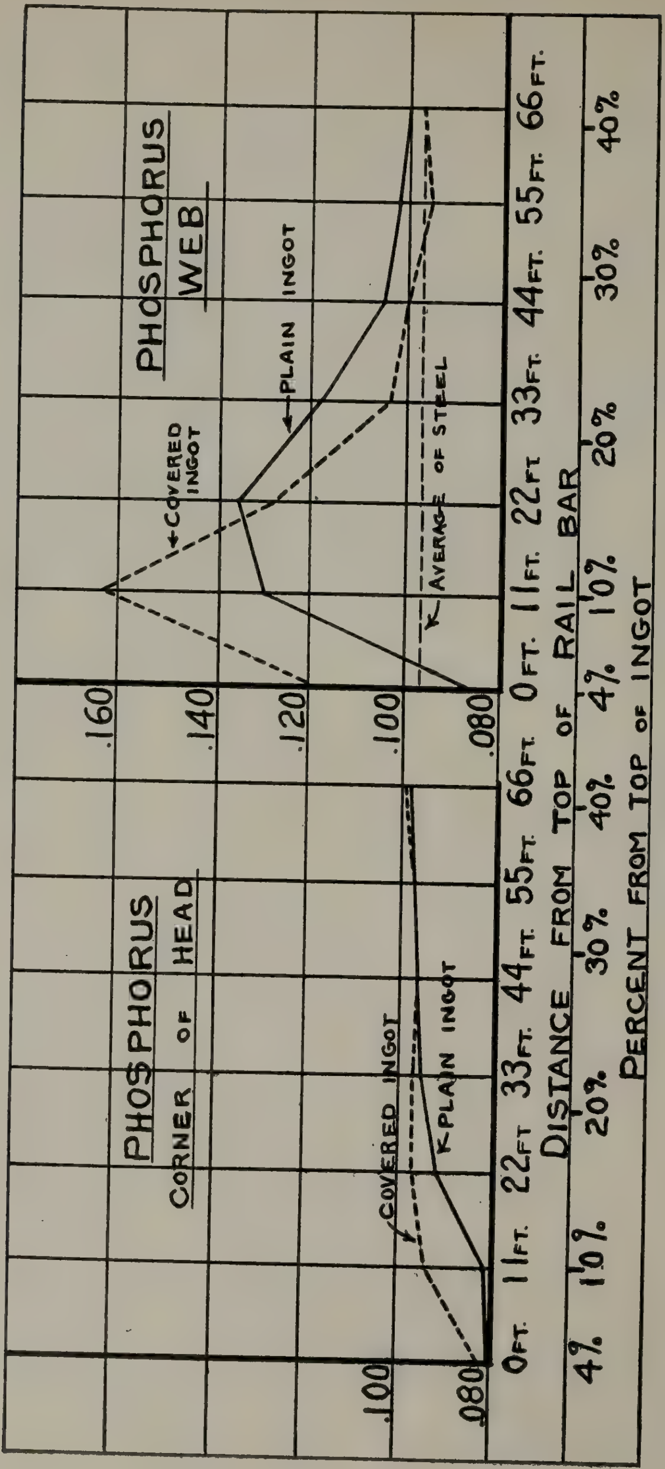


Fig. 3—Phosphorus Diagrams.

top end of the A rail, and in per cent. from the top of the ingot, are shown horizontally and the amount of phosphorus is shown vertically. One diagram shows the results from the corner of the head, comparing the plain with the covered ingot, and the other diagram shows the comparison of the results from the web. On this diagram is shown a line representing the average phosphorus in the two ingots, namely, .097 per cent. It will be noticed that the head samples in the plain ingot show negative segregation of phosphorus in samples at 0 and 11 ft., corresponding to 4 per cent. and 10 per cent., respectively, from the top of the ingot, while the covered ingot shows negative segregation only in the top sample. The other head samples show about the average phosphorus. Going now to the web samples, it will be noted that the plain ingot shows negative segregation in the top sample, while the covered ingot shows some positive segregation. The samples at 11 ft. both show marked segregation, the covered ingot especially so. In the samples at 22 ft., corresponding to 16 per cent. from the top of the ingot, the plain ingot shows a still further increase of phosphorus in the web, while the covered ingot drops a little below it. At 33 ft., the plain ingot still shows considerable segregation, while the covered ingot drops down to about the average of the steel. The samples from 44, 55 and 66 ft., in both ingots, roughly approximate the average phosphorus.

The results on carbon and sulphur are plotted in the diagrams shown in Fig. 4, and the remarks concerning phosphorus apply very closely to the sulphur also. The carbon, however, shows some vagaries which are puzzling. In the samples from the corner of the head, negative segregation is shown at the top of the rail bar in both ingots. In the plain ingot the other head samples approximate the average carbon, while in the covered ingot the carbon first goes up a little above the average and then a little below the average. In the samples from the web, the top of the rail bar shows about the average carbon in the plain ingot or a trifle below it, while in the covered ingot the carbon is a little above the average. In the samples at 11 ft. and 22 ft., the plain ingot shows carbon a little above the average, and in the covered ingot considerably so. From here on the curves drop very abruptly and then rise again, in a specially curious manner in the covered ingot. These irregularities of carbon are very puzzling, and whether they represent actual conditions or are due to exchange of samples or errors of analysis, it is hard to say, although the analytical work was done carefully.

The chemical results discussed above seem to show that the effect of the covering of fire-clay, as used in this experiment, is to run the segregation higher up in the ingot and also to increase its concentration. The increases of carbon, phosphorus and sulphur in the web, as compared with the average steel at distances of 11 ft. and 22 ft. from the top of the rail bar as sawed, representing distances of 10 per cent. and 16 per cent., respectively, from the top of the ingot, are shown for both ingots in table 2.

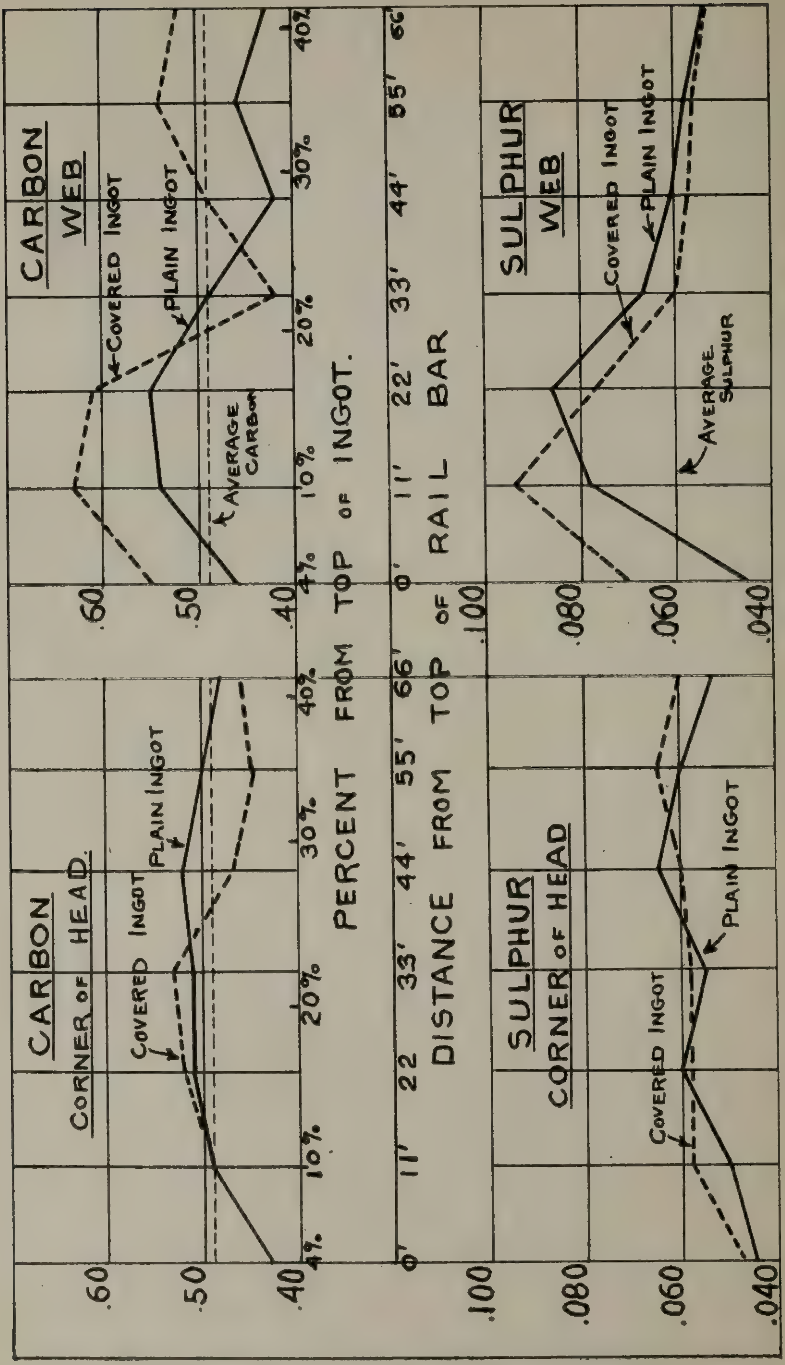


FIG. 4—CARBON AND SULPHUR DIAGRAMS.

TABLE 2—SEGREGATION.

	11 ft.		22 ft.	
	Plain.	Covered.	Plain.	Covered.
Average carbon.......	.49		.49	
Web	.54	.63	.55	.61
Increase	10%	29%	12%	24%
Average phosphorus..	.097		.097	
Web	.130	.163	.136	.128
Increase	34%	68%	40%	32%
Average sulphur.....	.060		.060	
Web	.078	.094	.086	.077
Increase	30%	57%	43%	28%

These figures seem to indicate that at a distance of 10 per cent. from the top of the ingot the concentration of the segregate is very much greater in the covered ingot, but at 16 per cent. somewhat greater in the plain ingot. These figures do not, however, give any information as to the area covered by the segregated metal in the sections of the rail, and judgment on this point must be withheld until the etched sections have been studied.

ETCHINGS.

Sections of one-half inch were taken at intervals of 11 ft. along each rail, polished and etched with copper-ammonium chloride solution. The etched sections from each ingot, at distances of 0, 11, 22, 33 and 44 feet along the rail bar, are reproduced as Figs. 5 to 14, inclusive. Fig. 5 shows the top of the rail bar of the plain ingot, representing 4 per cent. from the top of the ingot, and the section is seen to contain spots and streaks, distributed over the whole section. The corresponding section of the covered ingot is shown in Fig. 6, and this also shows a somewhat general distribution of spots and streaks, but it differs in showing some concentration of segregate into the web, which corresponds with the results of the analyses. Fig. 7 shows a section at 11 ft., or about 10 per cent. from the top of the plain ingot, which shows a few spots and streaks and also an area of segregate down through the web. The corresponding section of the covered ingot is shown in Fig. 8. This is comparatively free from spots and small streaks, but has a large, dark streak through the web, which the analysis shows must be rather concentrated segregate. The section at 22 ft., or 16 per cent. from the top of the plain ingot, is shown in Fig. 9. This shows a few spots and streaks throughout the section and also shows a darker area through the web, which the analysis shows to be high in carbon, phosphorus and sulphur. The corresponding section of the covered ingot is shown in Fig. 10, and shows a fairly even structure, with comparatively few spots and streaks. The sections at 33 ft. and 44 ft., representing respectively 23 per cent. and 29 per cent. from the top of the

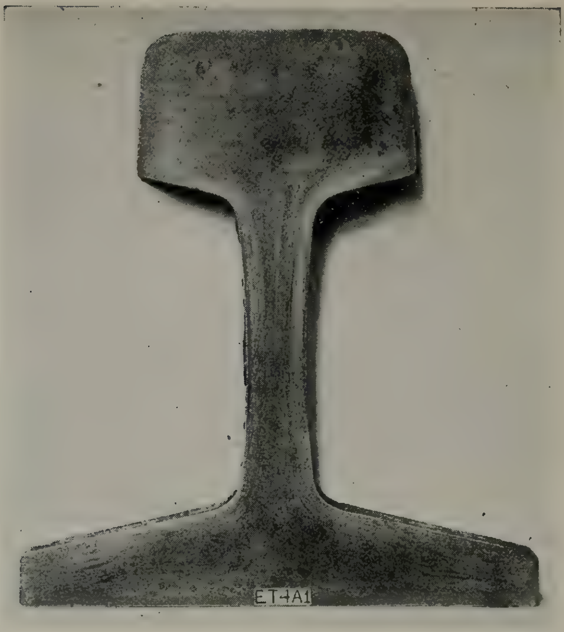


Fig. 5—Section at Top of Rail Bar—Plain Ingot—4 Per Cent. From Top of Ingot.

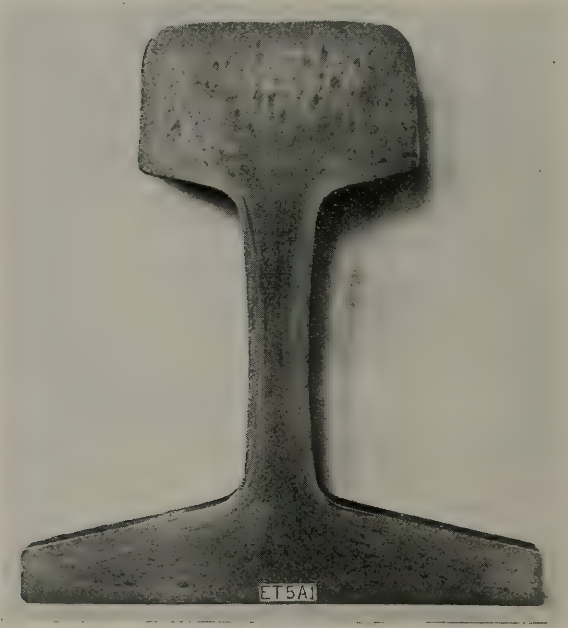


Fig. 6—Section at Top of Rail Bar—Covered Ingot—4 Per Cent. From Top of Ingot.

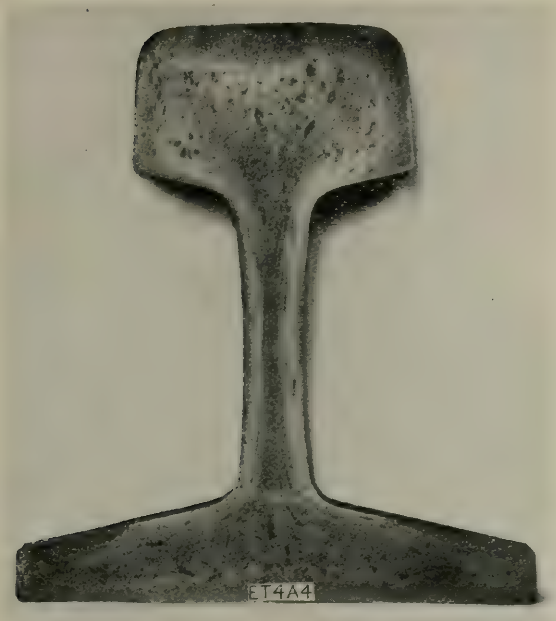


FIG. 7—SECTION AT 11-FT.—PLAIN INGOT—
10 PER CENT. FROM TOP OF INGOT.

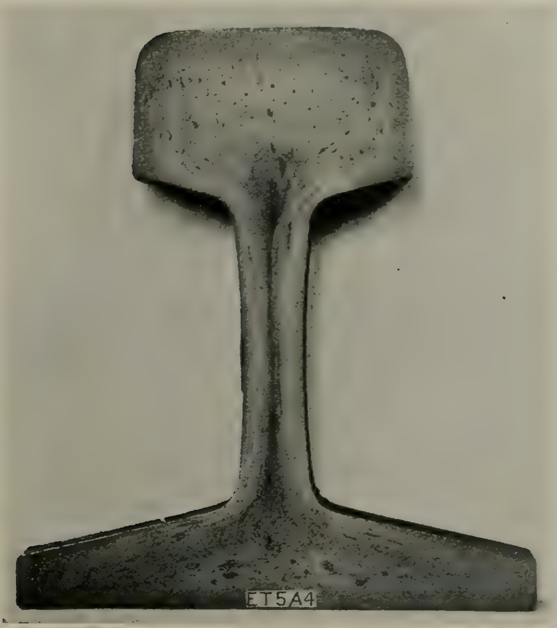


FIG. 8—SECTION AT 11-FT.—COVERED INGOT—
10 PER CENT. FROM TOP OF INGOT.

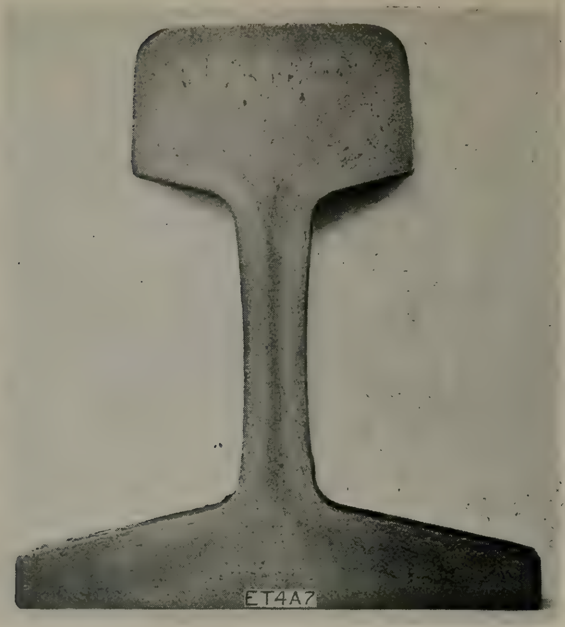


FIG. 9—SECTION AT 22-FT.—PLAIN INGOT—
16 PER CENT. FROM TOP OF INGOT.

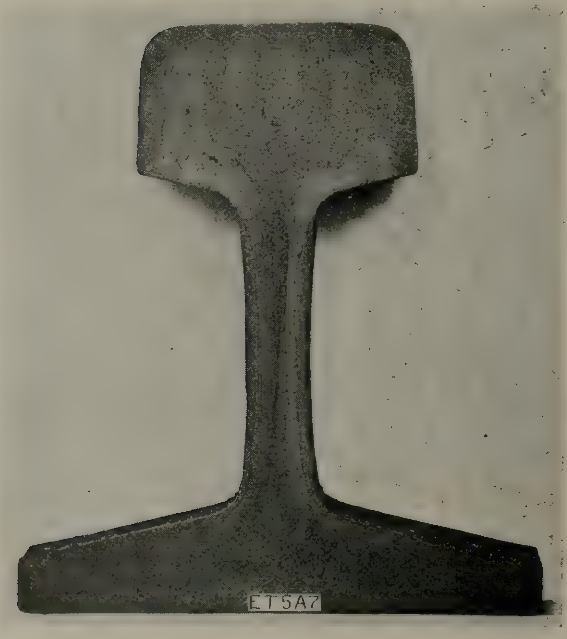


FIG. 10—SECTION AT 22-FT.—COVERED INGOT—
16 PER CENT. FROM TOP OF INGOT.

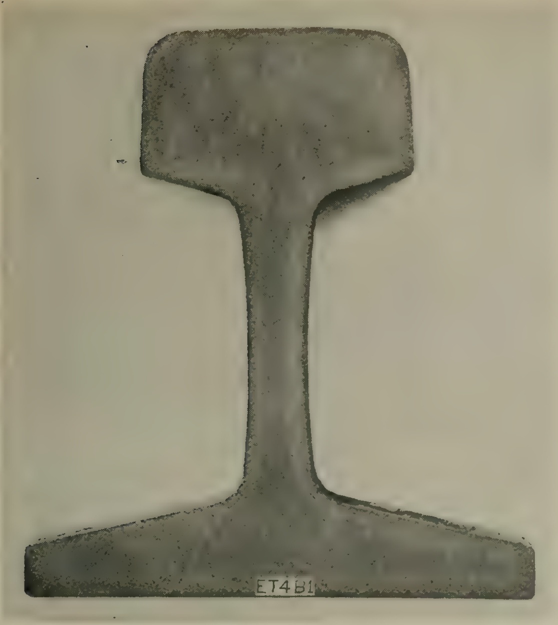


FIG. 11—SECTION AT 33-FT.—PLAIN INGOT—23 PER CENT. FROM TOP OF INGOT.

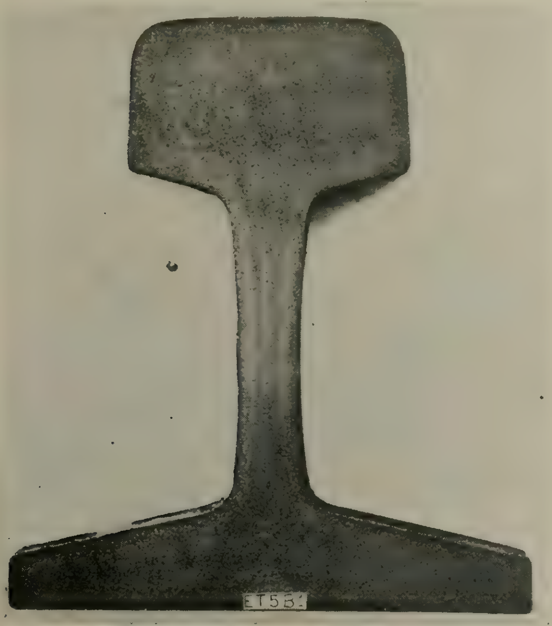


FIG. 12—SECTION AT 33-FT.—COVERED INGOT—23 PER CENT. FROM TOP OF INGOT.

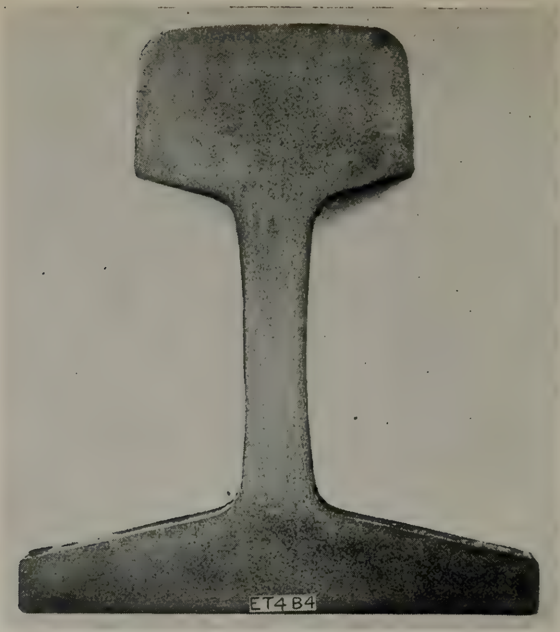


FIG. 13—SECTION AT 44-FT.—PLAIN INGOT—29 PER CENT. FROM TOP OF INGOT.

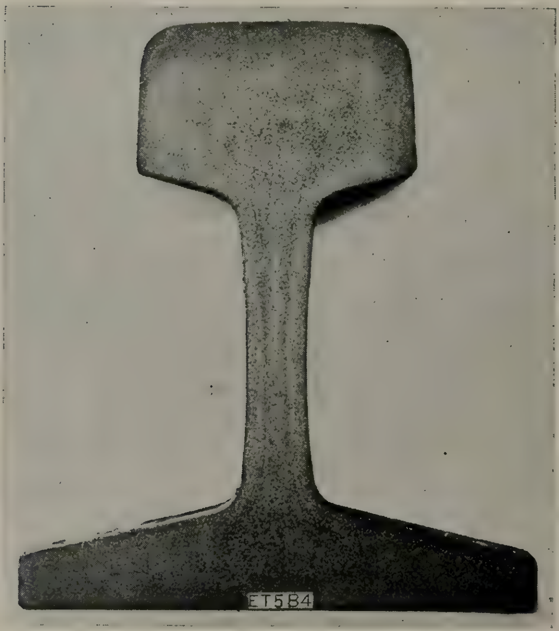


FIG. 14—SECTION AT 44-FT.—COVERED INGOT—29 PER CENT. FROM TOP OF INGOT.

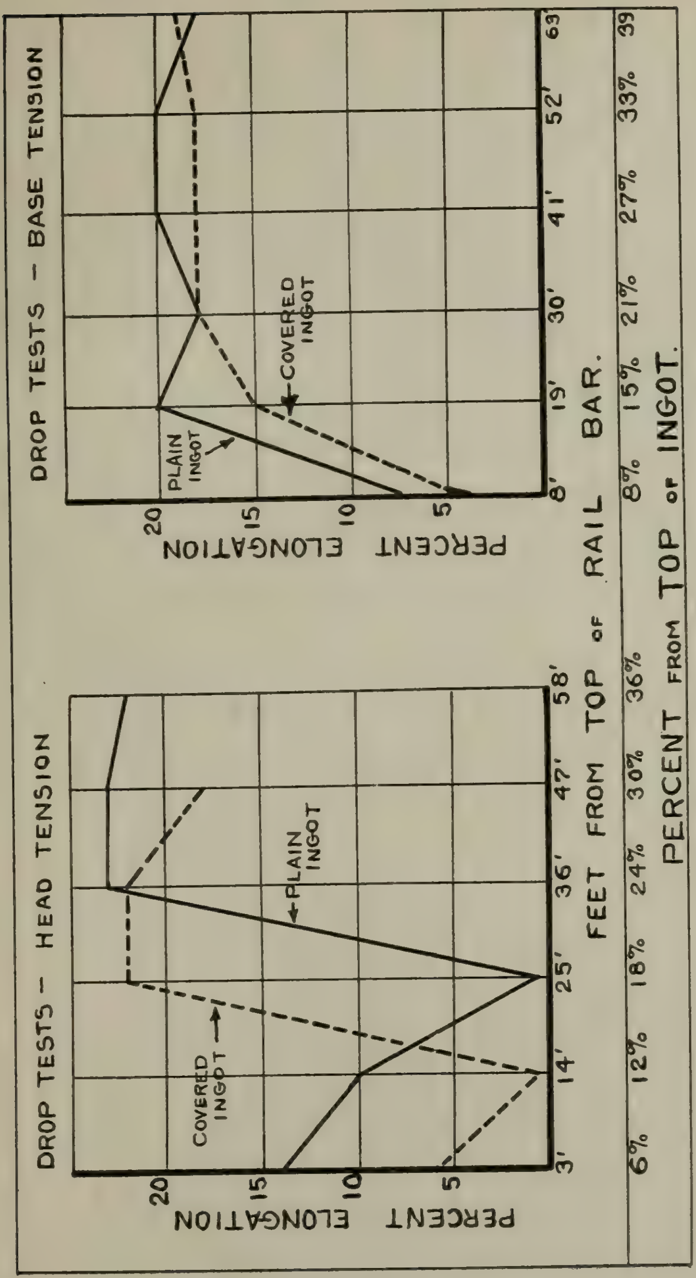


Fig. 15—Elongation Diagrams of Drop Tests.

ingot, show fairly even structures in both ingots and are reproduced in Figs. 11, 12, 13 and 14. The sections at 55 and 66 ft. showed very even structures in both ingots, but are not reproduced.

The indications of the etchings are similar to the showings of the analyses, namely, that the prominent segregation occurs higher in the covered than in the plain ingot.

DROP TESTS.

Six drop tests were made of each rail, three with the head in tension and three with the base in tension. The top was 2,000 lbs., the height of drop was 18 ft., the supports were three feet apart and the anvil was the standard spring-supported anvil of 10 tons. The deflection was taken as the distance between a three-foot straight-edge and the part of the rail struck by the tup. Gauge marks 1 inch apart were put on the side in tension for a distance of six inches and the stretch of each inch determined after each blow. The results of the drop tests are shown in tables as follows:

Table 3—Plain ingot, head tension.
Table 4—Covered ingot, head tension.
Table 5—Plain ingot, base tension.
Table 6—Covered ingot, base tension.

TABLE 3—DROP TEST, PLAIN INGOT, HEAD TENSION.

Test No.	No. of blow.	Deflection.	Length of 1-inch marks after blow.					
			1	2	3	4	5	6
ET4-A2	1	1.93	1.05	1.08	1.10	1.09	1.08	1.07
	2	Broke	1.07	1.11	1.14	1.13	....	1.07
ET4-A5	1	1.86	1.06	1.09	1.09	1.09	1.06	1.03
	2	Broke	1.07	1.10	....	....	1.08	1.06
ET4-A8	1	Broke	1.00	1.00	....	1.01	1.00	1.00
ET4-B2	1	1.82	1.06	1.08	1.09	1.09	1.08	1.05
	2	3.37	1.13	1.17	1.18	1.15	1.11	1.06
	3	4.76	1.17	1.22	1.22	1.19	1.16	1.10
	4	Broke	1.18	1.23	1.23	1.21	1.15	....
ET4-B5	1	1.81	1.06	1.07	1.09	1.09	1.08	1.05
	2	3.36	1.12	1.16	1.18	1.16	1.11	1.07
	3	4.78	1.16	1.22	1.23	1.21	1.16	1.10
	4	Broke	1.18	1.22	1.23	1.21	1.15	1.10
ET4-B8	1	1.84	1.05	1.06	1.09	1.08	1.07	1.05
	2	3.39	1.11	1.15	1.18	1.16	1.13	1.07
	3	4.86	1.13	1.18	1.22	1.20	1.17	1 11
	4	Broke	1.13	1.19	1.22	1.21	1.17	1.12

TABLE 4—DROP TEST, COVERED INGOT, HEAD TENSION.

Test No.	No. of blow.	Deflection.	Length of 1-inch marks after blow. 1	2	3	4	5	6
ET5-A2	1	Broke	1.04	1.05	....	1.06	1.05	1.04
ET5-A5	1	Broke	1.00	1.00	1.01	....	1.01	1.00
ET5-A8	1	1.86	1.06	1.07	1.09	1.09	1.08	1.05
	2	3.46	1.12	1.17	1.18	1.16	1.11	1.07
	3	Broke	1.14	1.19	1.22	1.20	1.15	1.11
ET5-B2	1	1.82	1.05	1.07	1.09	1.09	1.07	1.06
	2	3.37	1.11	1.15	1.18	1.16	1.12	1.08
	3	4.73	1.15	1.20	1.21	1.20	1.15	1.10
	4	Broke	1.16	1.20	1.22	1.20	1.16	....
ET5-B5	1	1.80	1.05	1.06	1.08	1.09	1.07	1.05
	2	3.38	1.07	1.11	1.15	1.17	1.15	1.11
	3	4.70	1.12	1.14	1.18	1.19	1.18	1.13
	4	Broke	1.12	1.15	1.18	....	1.18	1.14

ET5-B8 . Test spoiled account striking rail on wrong side.

TABLE 5—DROP TEST, PLAIN INGOT, BASE TENSION.

Test No.	No. of blow.	Deflection.	Length of 1-inch marks after blow.					
			1	2	3	4	5	6
ET4-A3	1	1.83	1.05	1.05	1.06	1.07	1.06	1.04
	2	Broke	1.05	....	1.06	....	1.06	1.05
ET4-A6	1	1.80	1.04	1.05	1.06	1.07	1.07	1.04
	2	3.32	1.10	1.12	1.13	1.13	1.11	1.08
	3	4.78	1.10	1.14	1.17	1.19	1.17	1.13
	4	Broke	1.11	1.15	1.16	1.20	1.18	1.15
ET4-A9	1	1.78	1.05	1.07	1.07	1.06	1.05	1.04
	2	3.22	1.10	1.12	1.12	1.11	1.09	1.06
	3	4.60	1.13	1.16	1.18	1.16	1.13	1.09
	4	Broke	1.13	....	1.18	1.16	1.14	1.11
ET4-B3	1	1.78	1.04	1.06	1.07	1.06	1.06	1.04
	2	3.29	1.09	1.12	1.13	1.12	1.09	1.07
	3	4.74	1.13	1.17	1.19	1.18	1.14	1.10
	4	Broke	....	1.18	1.20	1.19	1.16	1.11
ET4-B6	1	1.82	1.05	1.06	1.07	1.06	1.05	1.03
	2	3.33	1.10	1.12	1.13	1.12	1.10	1.08
	3	4.70	1.15	1.18	1.16	1.13	1.10	1.08
	4	6.42	1.17	1.20	1.20	1.17	1.14	1.10
Not broken	5	8.66	1.18	1.20	1.20	1.19	1.16	1.13
ET4-B9	1	1.81	1.04	1.05	1.06	1.06	1.05	1.04
	2	3.30	1.08	1.11	1.12	1.11	1.08	1.06
	3	4.78	1.11	1.14	1.16	1.16	1.12	1.09
	4	Broke	1.12	1.16	1.18	1.18	1.15	1.12

TABLE 6—DROP TEST, COVERED INGOT, BASE TENSION.

Test No.	No. of blow.	Deflection.	Length of 1-inch marks after blow. 1	2	3	4	5	6
ET5-A3	1	Broke	1.03	1.03	....	1.04	1.04	1.03
ET5-A6	1	1.80	1.04	1.06	1.06	1.07	1.06	1.04
	2	3.34	1.07	1.11	1.13	1.13	1.11	1.08
	3	Broke	1.08	1.12	....	1.15	1.13	1.10
ET5-A9	1	1.76	1.04	1.06	1.07	1.06	1.04	1.04
	2	3.25	1.09	1.12	1.12	1.11	1.09	1.06
	3	4.76	1.13	1.16	1.16	1.16	1.11	1.08
	4	Broke	1.13	1.17	1.18	1.16	1.12	1.09
ET5-B3	1	1.78	1.06	1.06	1.07	1.07	1.06	1.05
	2	3.32	1.09	1.11	1.12	1.12	1.10	1.08
	3	4.84	1.12	1.14	1.16	1.16	1.13	1.09
	4	Broke	....	1.16	1.18	1.17	1.13	1.10
ET5-B6	1	1.84	1.05	1.06	1.06	1.06	1.05	1.04
	2	3.34	1.08	1.10	1.12	1.12	1.10	1.08
	3	4.85	1.11	1.14	1.18	1.16	1.14	1.10
	4	Broke	1.12	1.15	1.18	1.17	1.15	1.11
ET5-B9	1	1.80	1.04	1.05	1.06	1.06	1.05	1.04
	2	3.34	1.05	1.08	1.11	1.13	1.12	1.09
	3	4.85	1.09	1.13	1.16	1.18	1.16	1.13
	4	6.70	1.11	1.14	1.18	1.20	1.18	1.15
	5	Broke	1.12	1.16	1.18	....	1.10	1.16

Probably the best way to compare the results of the drop tests is on the basis of the maximum elongation given by the metal after breaking, and for convenient comparison I give the elongation results in table 7:

TABLE 7—MAXIMUM ELONGATION IN DROP TESTS.

		Head Tension.		Base Tension.	
		Plain	Covered	Plain	Covered
Rail.	Distance	Ingot.	Ingot.	Ingot.	Ingot.
A	1st, 11 ft.	14%	6%	7%	4%
	2nd, 11 ft.	10	1	20	15
	3rd, 11 ft.	1	22	18	18
B	4th, 11 ft.	23	22	20	18
	5th, 11 ft.	23	18	20	18
	6th, 11 ft.	22	..	18	19

These results are also shown graphically in Fig. 15, which should be studied closely, as I think it displays some significant information. Considering the tests with the head in tension, it will be noticed that the ductility at first decreases as we go down the ingot until a very brittle point is reached, which was found at 18 per cent. down from the top in the plain ingot and 12 per cent. down in the covered ingot. Of course, it must be remembered that the tests with head tension were made at distances 6 per cent. apart, so that the point or zone of brittleness could not be located closely, but it is evident that there is such a brittle place in the rail from both ingots and that it occurs lower down in the plain than in the covered ingot, and further, that the usual discard of about 10 per cent. from the top would not remove it from either of these two ingots. Going still farther down the ingot, we rapidly pass the brittle zone and the metal shows good ductility down to 36 per cent., where the tests ceased, although other tests have shown that the good ductility continues for the rest of the ingot.

Considering now the tests with the base in tension, it will be seen that the first test represents a distance of 8 feet from the top of the finished rail bar, or 8 per cent. from the top of the ingot. This means that the place where the tup struck the rail was this distance down. The ductility is low at this place, especially in the covered ingot. The ductility rapidly rises, however, as we go down the ingot, with no evidence of a very brittle zone, which shows only 1 per cent. stretch when broken. Consideration of this matter and the fractures in drop tests show that this test is essentially a tension test of the part in tension, as failure generally starts in the part in tension, although occasionally, with very ductile material, failure occurs by shear along the neutral plane, and the study of fractures also shows that failure does not often start at the outer fibers, where the metal is stretched most, but internally, where the metal seems to be least ductile. An internal area of brittle material in the head or base seems to determine failure, even though the outer fibers may be very ductile.

Strongly segregated metal does not extend into the base to the extent that it does into the head, and, therefore, it is reasonable to expect that it would not show its influence as promptly when a rail is drop tested with base tension as with head tension. I give this as appearing to me to be a consistent explanation of the difference between the head tension and base tension curves, although it will take considerably more experiment to work this matter out.

The results showing the deflection after the first blow also make an interesting study, and I give these results in table 8.

TABLE 8—DEFLECTION AFTER FIRST BLOW IN DROP TESTS.

		Head Tension.		Base Tension.	
Rail.	Distance	Plain Ingot.	Covered Ingot.	Plain Ingot.	Covered Ingot.
A	1st, 11 ft.	1.93	Broke	1.83	Broke
	2nd, 11 ft.	1.86	Broke	1.80	1.80
	3rd, 11 ft.	Broke	1.86	1.78	1.76
B	4th, 11 ft.	1.82	1.82	1.78	1.78
	5th, 11 ft.	1.81	1.80	1.82	1.84
	6th, 11 ft.	1.84	....	1.81	1.80

The deflection is just about the same for both ingots and is seen to first decrease a little as we go down the ingot and then to increase again to about 40 per cent. down from the top, the limit of this investigation, but other tests have shown that the deflection continues to increase in amount to about the bottom of the ingot. This means that, starting from the top of the ingot, the rail bar first increases in stiffness as measured by the drop test and then decreases in stiffness, the maximum stiffness seeming to be about 30 per cent. down with head tension and about 20 per cent. down with base tension, according to the indications of these particular tests. The extremes here vary by 7 per cent. with head tension and only 3 per cent. with base tension, which again suggests that the base is less affected by the interior segregation.

Diagrams of the fractures obtained in the drop tests with head tension are shown in Fig. 16 and with base tension in Fig. 17. It will be noted that in the three pieces from the A rail of the plain ingot with head tension the fracture started in the interior of the head, and this was also the case in the first two pieces from the covered ingot. In the other pieces with head tension the fracture started in or near the neutral plane, due, presumably, to the shear between the part in tension and that in compression. In these latter cases the rail gave considerable deflection before breaking. With base tension the fracture in most cases started in the interior of the base, although in samples ET5-B3 and ET5-B6 from the covered ingot the fracture started in the web, also due, perhaps, to shear. Sample ET5-A9 from the covered ingot, representing a distance of 21 per cent. from the top, had a lamination in the web one inch wide, and

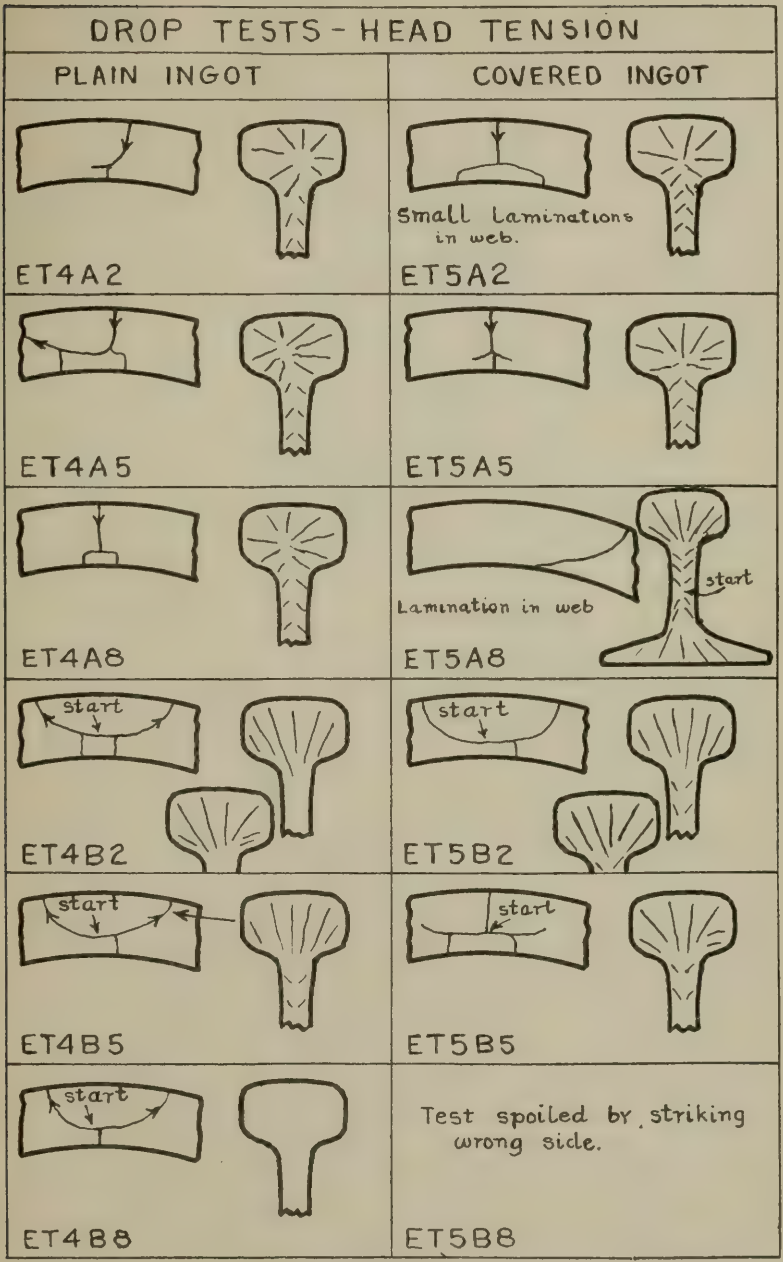


Fig. 16—Fractures With Head in Tension.

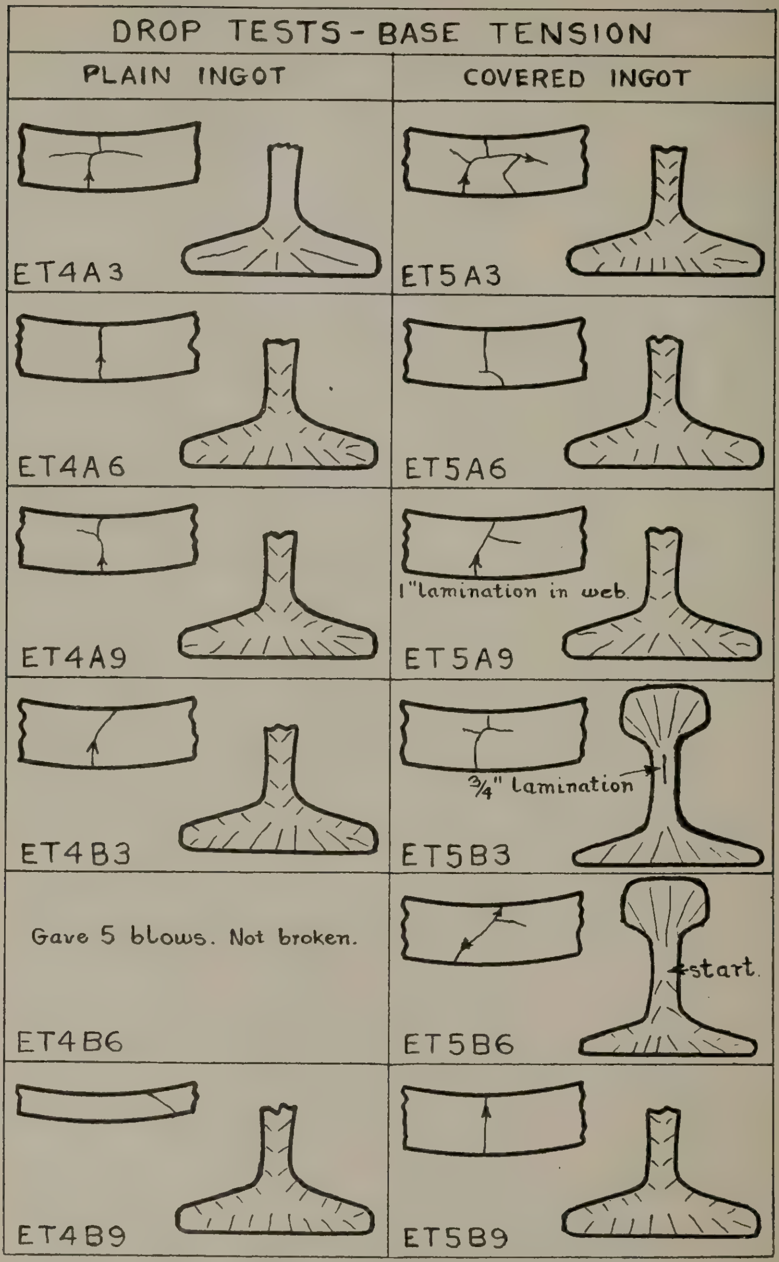


Fig. 17—Fractures With Base in Tension.

sample ET5-B3, from the same ingot, representing 27 per cent. from the top, had a ¾-inch lamination in the web. It is interesting to note that it took four blows in both of these cases to break the rail.

The approximate height which would have been just sufficient to cause fracture is shown in table 9. This was determined by taking the elongation at the last blow which did not cause fracture and figuring that each per cent. elongation beyond this with head tension was due to 2.0-foot drop and each per cent. increase with base tension was due to 2.7-foot drop, the average maximum elongation as the result of the first blow from 18 feet having been at 9.1 per cent. with head tension and 6.7 per cent. with base tension.

TABLE 9—HEIGHT OF DROP JUST SUFFICIENT TO CAUSE FRACTURE.

Head Tension.			Base Tension.		
Per Cent. From Top.	Plain Ingot.	Covered Ingot.	Per Cent. From Top.	Plain Ingot.	Covered Ingot.
6%	26 ft.	12 ft.	8%	18 ft.	11 ft.
12	20	2	15	57	41
18	2	44	21	53	59
24	56	56	27	53	59
30	58	56	33	over 92	57
36	56	..	39	53	77

CONCLUSION.

This study seems to show that with a Bessemer ingot weighing about 5,000 lbs. the effect of covering it with fire-clay directly after pouring is to cause the greatest segregation to go higher toward the top of the ingot and also to increase its concentration. A small discard, say less than 10 per cent. from the top, does not remove the zone of maximum segregation from either the plain or covered ingot, and the segregation would be worse in the covered ingot. A large discard of 20 per cent. or over removes it more effectively from the covered ingot. This whole study, however, can be taken only as an indication and seems to show strongly the need for a thorough study of the whole subject of ingot-making. Ingots of different sizes and shapes, made of both Bessemer and open-hearth steels and with different treatments, should be made and thoroughly studied, by testing the rails made from them and, what is perhaps more important, by also testing the ingots themselves. Etchings and analyses should be made of various ingot sections to determine accurately the distribution of the various metalloids and of cavities, slag, etc.

The rails for the above tests and all the analyses and test facilities were kindly furnished by the Carnegie Steel Co., to whom the thanks of the Rail Committee are due.

STRENGTH OF RAIL HEAD.

By M. H. Wickhorst, Engineer of Tests, Rail Committee.

This report covers tests made to determine the strength of the head of the rail with the load concentrated at the edge of the top surface. Tests were made with a 200,000-pound test machine by canting a piece of rail 18 inches long and applying the load at the edge by means of a block with a radius of 16½ inches to represent a car wheel where it came in contact with the rail. Other tests were made with a reciprocating machine representing a loaded wheel rolling back and forth on the edge of the canted rail. These tests were made at Sparrows Point, Md., at the works of the Maryland Steel Company, who kindly furnished all the material and facilities for them, and were made especially for the sub-committee dealing with rail design. For these tests a rail was taken from stock and six pieces, each 18 inches long, were cut from it for test in the stationary test machine, and six similar pieces were used for test in the reciprocating machine. In order to have the material as uniform as possible throughout the section and in the different pieces a C rail was selected, that is, the third rail from the top of the rail bar. The rail was a 90-pound A. R. A. type B section and the pieces were planed down to thicknesses of head at the side of ⅜ in., ½ in., ⅝ in., ¾ in., ⅞ in., and 1 in., two pieces of each thickness, one for each kind of test. In each case the brand side of the head of the rail, which was the bottom side as rolled, was planed vertical to a width of 1 3/16 inch from the center line. Fig. 1 shows the dimensions of the section used and also gives diagrams of the pieces as tested. The essential dimensions of the head of the pieces tested as indicated by letters A, B and C, on Fig. 1, measured as shown in Table 1.

Report No. 9, November, 1910.

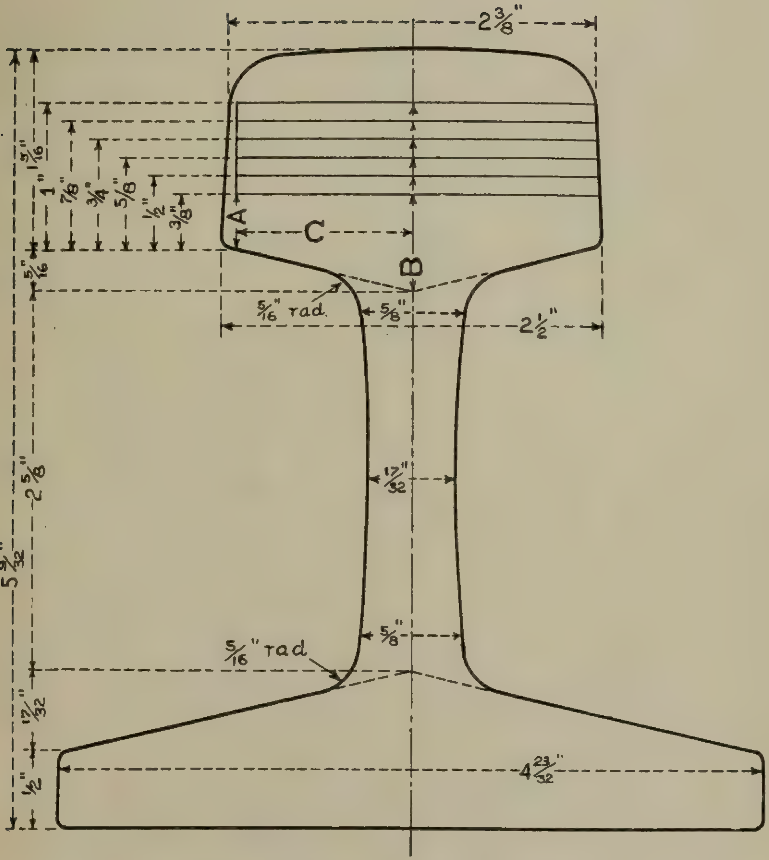


FIG. 1—DIAGRAMS OF PIECES TESTED.

TABLE I—DIMENSIONS OF HEADS AS TESTED.

Test Nos.	Thickness of Head. Edge A	Thickness of Head. Center B	Width. Side to Center C
1 and 2	1.02	1.26	1.15
3 and 4	.91	1.15	1.18
5 and 6	.76	1.02	1.17
7 and 8	.62	.86	1.15
9 and 10	.51	.75	1.16
11 and 12	.38	.64	1.17

Two samples were taken with a ½-inch drill for analysis from a section near the middle of the length of the rail, one close to the upper corner and the other at the junction of the head and the web. The results of the analyses are shown in Table 2:

TABLE 2—ANALYSES.

	Corner of Head.	Junction of Head and Web.
Carbon	.538	.523
Phosphorus	.070	.070
Sulphur.	.050	.055
Manganese	.81	.81
Silicon	.103	.103
Copper	.19	.18
Nickel	None.	None.
Chromium	"	"

These results show the material to be very uniform.

Tensile tests were also made of pieces cut from near the middle of the rail, two pieces ½ in. diameter and 2-in. gage length, for longitudinal test from the center of the head, and two pieces ½ in. diameter and 1-in. gage length for transverse test across the center of the head. The yield point in the 2-in. pieces was determined by means of a Capp's multiplying dividers. The results of the tests are shown in Table 3:

TABLE 3—TENSILE TESTS.

	Yield Point lbs. per sq. in.	Ten. Strength lbs. per sq. in.	Elongation.	Reduction of Area.
Longitudinal ....a	51,000	111,600	16	29
2-in. gage length....b	52,700	111,500	16.5	29
Average	51,850	110,550	16.3	29
Transverse ....a	......	110,200	6	7
1-in. gage length.....b	......	111,200	7	9
Average	......	110,700	6.5	8

These results show material of good ductility longitudinally and the stretch crosswise of the head shows up well for a transverse test.

STATIONARY TESTS.

The arrangement used for making the stationary tests is shown in Fig. 2 and is intended to represent a 33-inch car wheel resting on the edge of the top of the rail. The head is thus tested as a cantilever, the load tending to sag the head locally and to also bend the web.

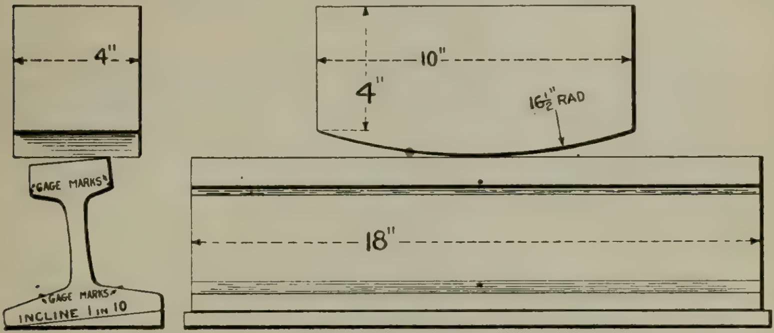


Fig. 2—Method of Stationary Tests.

The load was applied in increments of 10,000 lbs. up to 60,000 lbs. and then in increments of 20,000 lbs. up to 200,000 lbs., the capacity of the test machine. The sag of the head was determined by measuring the distance by means of dividers, between prick punch marks placed on the side of the head near the bottom and on the base, as indicated in Fig. 2, the load being on while taking the reading. The marks on the base were placed about one inch from the web, by gouging some of the metal so as to have a vertical surface on which to prick punch the mark. The amount that the opposite side of the head elevated or the "lift" was determined in a similar manner. The results of these tests are shown in Table 4.

TABLE 4—STATIONARY TESTS IN TEST MACHINE.

	⅜" Head.		½" Head.		⅝" Head.		¾" Head.		⅞" Head.		1" Head.	
Load.	Sag.	Lift.	Sag.	Lift.	Sag.	Lift.	Sag.	Lift.	Sag.	Lift.	Sag.	Lift
10,000	.00	.00	.00	.00	.00	.00	.00	.01	...	...	.00	.00
20,000	.02	.00	.01	.00	.01	.00	.00	.01	.01	.02	.00	.00
30,000	.05	.00	.02	.01	.02	.00	.01	.01	.01	.02	.01	.00
40,000	.06	.01	.03	.01	.04	.00	.01	.02	.02	.02	.02	.01
50,000	.08	.01	.04	.01	.06	.01	.02	.02	.03	.03	.02	.01
60,000	.09	.02	.05	.02	.07	.01	.03	.02	.04	.03	.03	.02
80,000	...	...	.06	.02	.10	.02	.04	.03	.05	.04	.04	.02
100,000	...	...	.07	.02	.11	.03	.05	.03	.06	.04	.04	.02
120,000	...	...	.08	.02	.12	.03	.07	.03	.07	.04	.05	.03
140,000	.15	.03	.09	.02	.13	.03	.08	.03	.08	.04	.05	.03
160,000	.17	.03	.10	.02	.14	.04	.08	.03	.08	.04	.06	.03
180,000	.20	.05	.11	.02	.15	.04	.09	.03	.09	.04	.07	.03
200,000	...	...	.13	.02	.16	.04	.10	.03	.10	.03	.08	.02

These results are plotted in Fig. 3, in which the load is plotted against the sag of head for each thickness of head tested. The ⅝-inch head, according to these curves, gave a greater sag than the ½-inch head. Although this is according to the measurements obtained, it would seem to be in error, due perhaps partly to errors of measurement, but probably also due to some condition I cannot account for, as for instance application of the load.

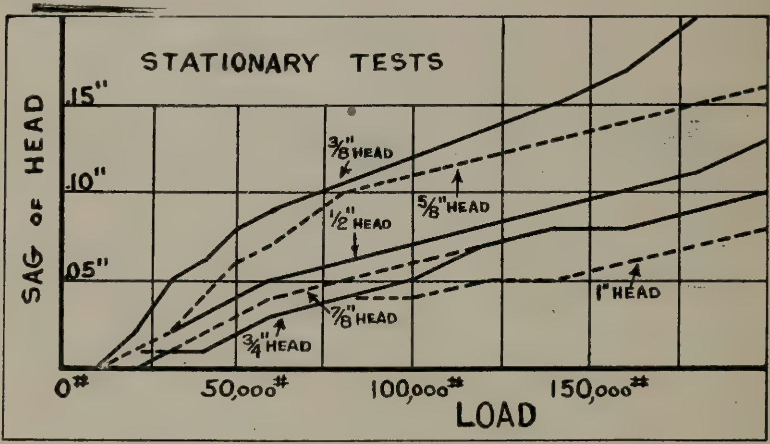


Fig. 3—Sag of Head in Stationary Tests.

The curves show that a load of 10,000 lbs. does not sag the head with the load applied to the edge of the top side, with any thickness down to ⅜ inch, and probably neither does a load of 20,000 lbs., although, as the load was on when the measurement was taken, we cannot say how much of the sag was elastic and how much permanent. A load of 30,000 lbs. seems to cause a permanent sag with the ⅜-inch head, but not much, if any, with the heads of greater thickness. It had been hoped to determine by these tests the maximum load which each thickness of head would carry, but it is now clear that in any future work of this kind the measurements should be taken after releasing each load, as well as while it is on, and it would also be desirable to make the measurements with a micrometer reading to .001 inch. With these changes it would seem that this test should give this information in a reasonably satisfactory manner.

Fig. 4 gives a side view of the rails after test to show the sag of the head under a load of 200,000 lbs., and Fig. 5 gives a top view to show the bearing taken under this load, the contact surfaces having been rubbed over with white chalk to show up distinctly.

It is interesting to note in this connection that the web seemed to stand the load of 200,000 lbs. successfully.

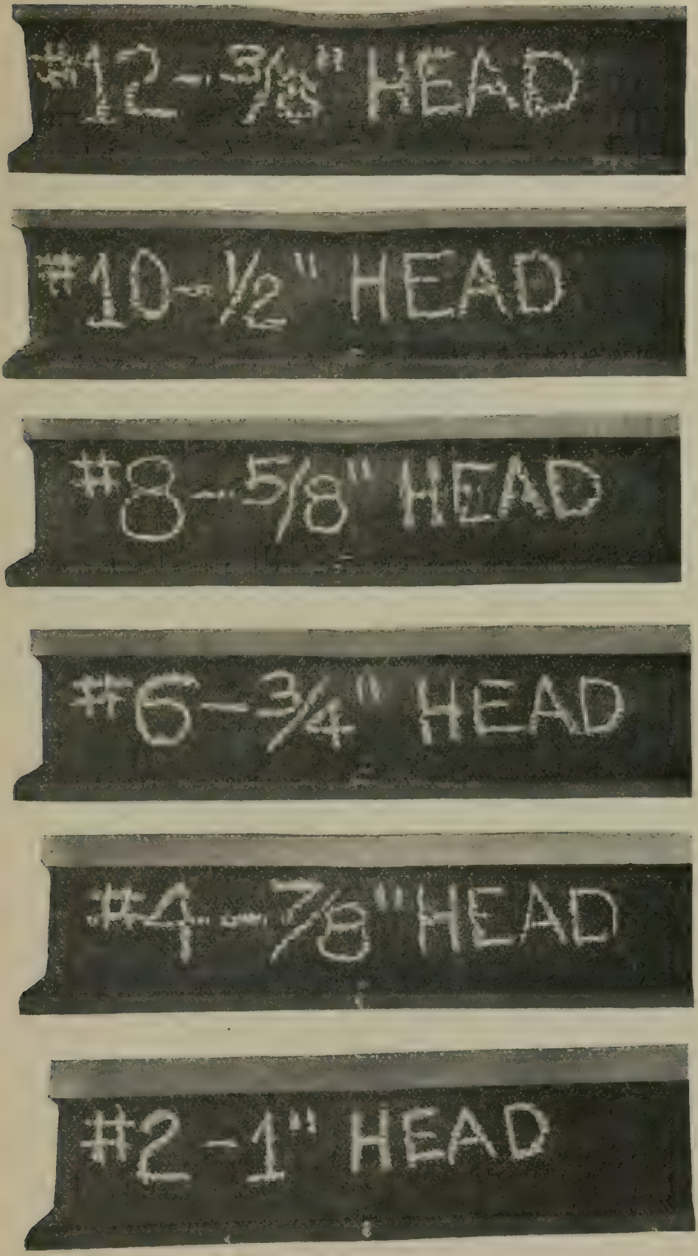


FIG. 4—STATIONARY TEST WITH LOAD OF 200,000 LBS.

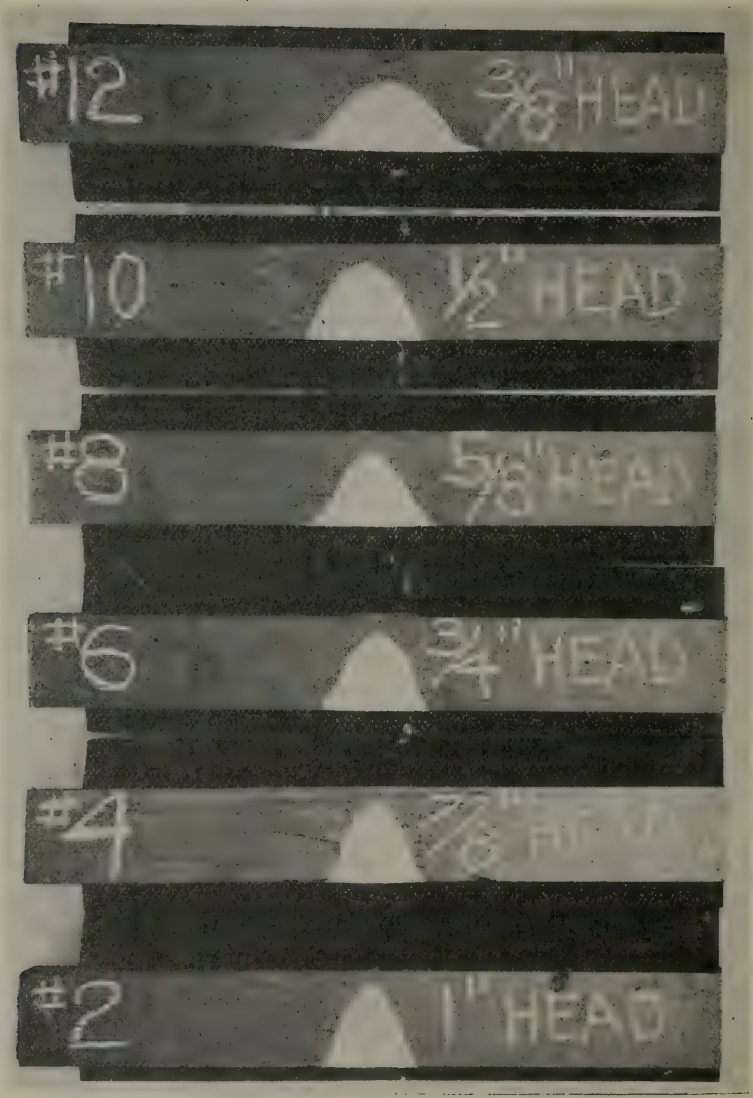
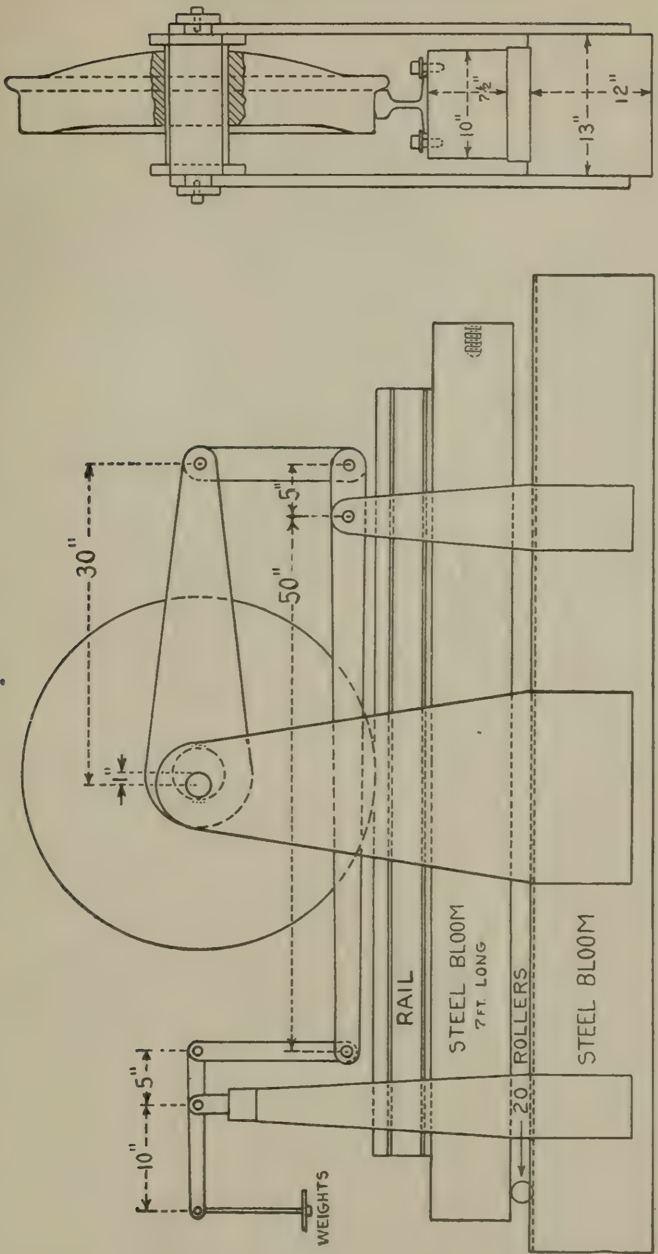


FIG. 5—SHOWING SURFACES OF CONTACT AFTER APPLICATION OF LOAD OF 200,000 LBS.


10"
7½"
13"
12"
30"
5"
50"
1"
5"
10"
WEIGHTS
RAIL
STEEL BLOOM
7 FT. LONG
ROLLERS
20
STEEL BLOOM

ROLLING TESTS.

Tests were also made with a reciprocating machine in which a piece of rail is moved back and forth under a wheel to which a load can be applied by means of a system of levers. A diagram of the machine is shown in Fig. 6, from which it is seen that the rail is fastened to a steel bloom which runs on rollers running on another steel bloom that forms the bed of the machine. The rail bed is connected by means of a connecting rod to the bed plate of a planer, which furnishes the power to run the rail machine. The weights attached to the weight hanger are multiplied 600 times as applied to the axle of the wheel, and in these tests weights of 50, 100 and 150 lbs. were used, so that the wheel loads were 30,000, 60,000 and 90,000 lbs., respectively. A piece of rail 18 inches long was tilted on an inclined plane of 1 in 10, as in the other tests, and the wheel, loaded with 30,000 lbs., was run back and forth over a length of about 10 inches for 100 double strokes, which made 200 movements of the loaded wheel over the rail, equivalent to a 50-car train, each wheel of which carried a load of 30,000 lbs. This is equivalent to a gross car weight of 120 tons. The sag of the head and the width of the bearing taken by the wheel were then measured with no load; the load was then increased to 60,000 lbs. and the wheel again run on the rail as before. The measurements were again taken and a final test made with a load of 90,000 lbs. The results of these tests proved to be interesting and fairly definite, and I show them in Table 5.

TABLE 5—RESULTS OF ROLLING TESTS.

Thickness of Head.	Sag of Head.			Width of Bearing.		
	30,000 lbs.	60,000 lbs.	90,000 lbs.	30,000 lbs.	60,000 lbs.	90,000 lbs.
⅜"	.05	.13	.17	.56	1.20	1.56
½"	.01	.08	.13	.34	1.00	1.42
⅝"	.00	.05	.13	.31	.76	1.40
¾"	.00	.03	.10	.32	.70	1.28
⅞"	.00	.01	.08	.32	.58	1.16
1"	.00	.00	.05	.28	.60	1.00

The results showing the relation of thickness of head and sag of head under loads of 30,000, 60,000 and 90,000 lbs. are plotted in Fig. 7. It will be noted that 30,000 lbs. produces no sag when the head is ⅝ inch or over in thickness. With 60,000 lbs. the head must be 1 inch or over in thickness. All the samples tested sagged under 90,000 lbs., but by extending the curve, it seems probable that a head 1⅜ inches thick would hold up a rolling load of 90,000 lbs. when concentrated at the edge.

Curves showing the relation of the thickness of head to the width of the bearing taken by the rolling wheel are shown in Fig. 8. On a head that does not sag, under the conditions of these tests and with the metal used, the bearing formed on the rail by a rolling wheel loaded with 30,000 lbs. becomes about .3 inch wide, and with 60,000 lbs., about .6 inch wide.

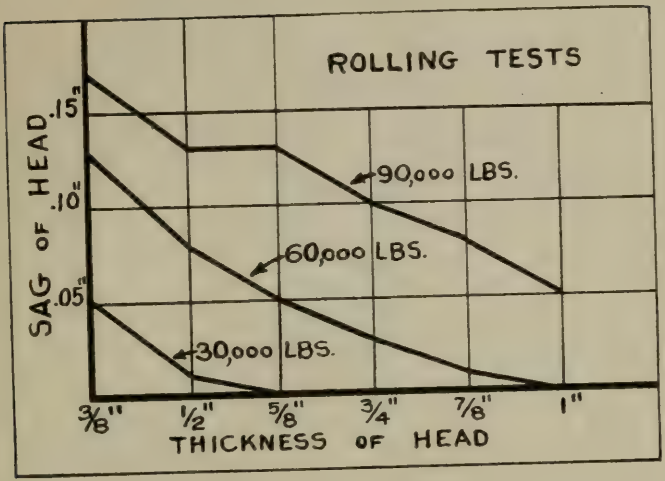


FIG. 7—SAG OF HEAD IN ROLLING TESTS.

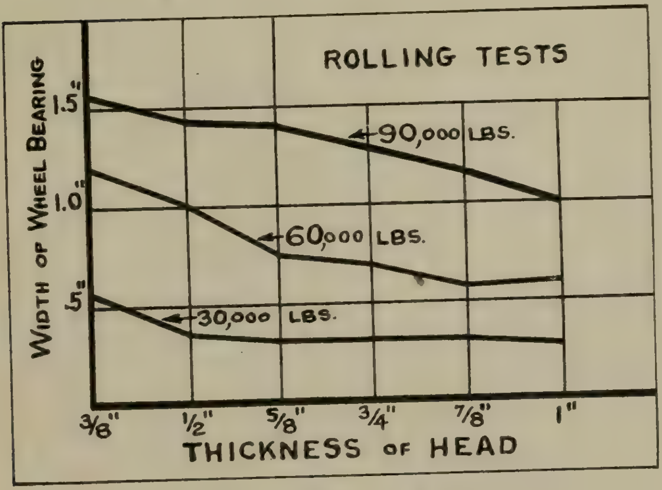


FIG. 8—WIDTH OF BEARING IN ROLLING TESTS.

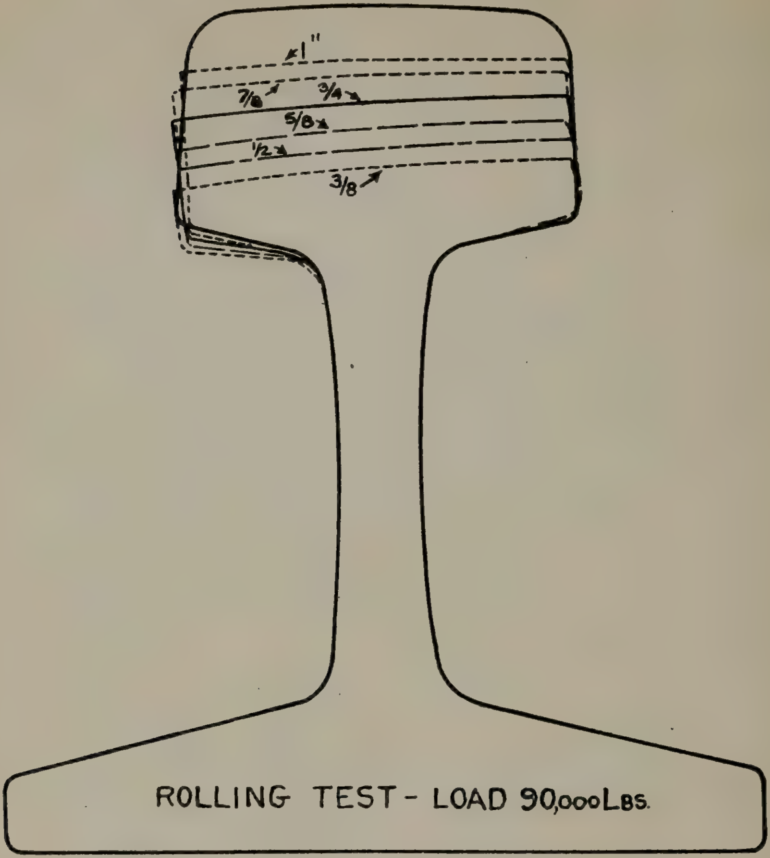


FIG. 9—RAILS AFTER ROLLING TEST WITH LOAD OF 90,000 LBS.

After the rails were tested they were cut in two and their sections are shown in comparison with the original rail section in Fig. 9.

It will be noted that the rolling load of 90,000 lbs. applied at the edge of the head produced very little or no bending of the web with the section used, which was a 90-lb. A. R. A. type B, with a thickness of 17-32 inch at the middle.

DROP TESTS OF RAILS.

EFFECT OF IMPACT ENERGY VARIOUSLY DISTRIBUTED.

By M. H. WICKHORST, Engineer of Tests, Rail Committee.

The tests described in this report were made to compare the results of a given amount of impact energy, variously distributed, as, for instance, in one blow, and the same foot-pounds divided among several blows; also, for instance, the relative effects of tups of different weights, but with heights adjusted to deliver the same foot-pounds of impact. The tests were made at Sparrows Point, Md., at the works of the Maryland Steel Co., who kindly furnished all the facilities and material for the work. The standard rail drop machine was used with a 10-ton spring-supported anvil and supports 3 ft. apart. Two tups were used, one the standard 2,000-lb. tup and the other a special tup of 6,000 lbs. An A. R. A. type B, 90-lb. open-hearth rail was taken from stock and in order to have the various pieces cut from the rail as uniform as possible, a C rail, that is, the third rail from the top of the rail bar, was selected, heat number 5010. A piece 18 inches long was cut from the top end of the rail for analyses and tensile tests and the rest of the rail was cut into lengths of 4½ ft. for drop tests.

Two samples were taken for analysis with a ½-in. drill lengthwise of the rail, one near the upper corner of the head and the other from the interior of the head near its junction with the web. The results of these analyses are shown in Table 1.

TABLE I—ANALYSES.

	Corner of Head.	Junction Head and Web.
Carbon	.718	.679
Phosphorus	.014	.015
Sulphur	.033	.037
Manganese	.68	.68
Silicon	.064	.066
Copper	.09	.09
Nickel and cobalt	.31	.30
Chromium	.21	.19

Report No. 10, December, 1910.

These results show uniform chemistry throughout the section, except that the carbon shows about .04 per cent. lower in the interior of the section than the outer part.

Samples for longitudinal tensile tests were taken from locations similar to those used for the chemical samples, duplicate samples being taken from each location, ½-in. diameter by 2-in. gage length. Duplicate samples were also taken for transverse test across the middle of the head, ½-in. diameter by 1-in. gage length. The yield point in the pieces with 2-in. gage length was determined by means of a Capp's multiplying dividers. The results of the tensile tests are shown in Table 2.

TABLE 2—TENSILE TESTS.

	Yield Point lbs. per sq. in.	Tensile Strength lbs. per sq. in.	Elongation per cent.	Reduction of area per cent.
Longitudinal	63,500	131,000	13.5	23
Corner of head	64,000	130,000	13	21
Average	63,750	130,500	13.3	22
Longitudinal	62,800	127,500	11	15
Interior of head........	64,500	127,500	12	18
Average	63,650	127,500	11.5	16.5
Transverse		129,300	5	6
1-in. gage length........		130,700	5	5
Average		130,000	5	5.5

These results show fairly uniform material of good ductility, although the interior of the rail seems to have a little lower tensile strength and a little less ductility.

DROP TESTS.

The drop tests were all made with the base in tension, the rail being place with its base downward on supports 3 ft. apart with radii of 5 in. The permanent deflection or set was measured both on the top side, including the depression caused by the tup, with a striking radius of 5 in., and on the base side, which latter measurement gave only the actual permanent bending of the rail. The deflection gage used is shown in Fig. 1, which was copied after one used by Mr. J. A. Colby in tests he has made for Mr. C. S. Churchill. The stretch of the bottom of the base was measured by putting gage marks one inch apart over a distance of 6 in. lengthwise on the base. The stretch of each inch was determined in .01 in. after each blow, by means of a fine-pointed toolmaker's dividers and a steel scale reading to .02 in.

Tests were made with the 6,000-lb. tup, using a height of 5 ft., with results as shown in Table 3. By mistake the first blow was given at a

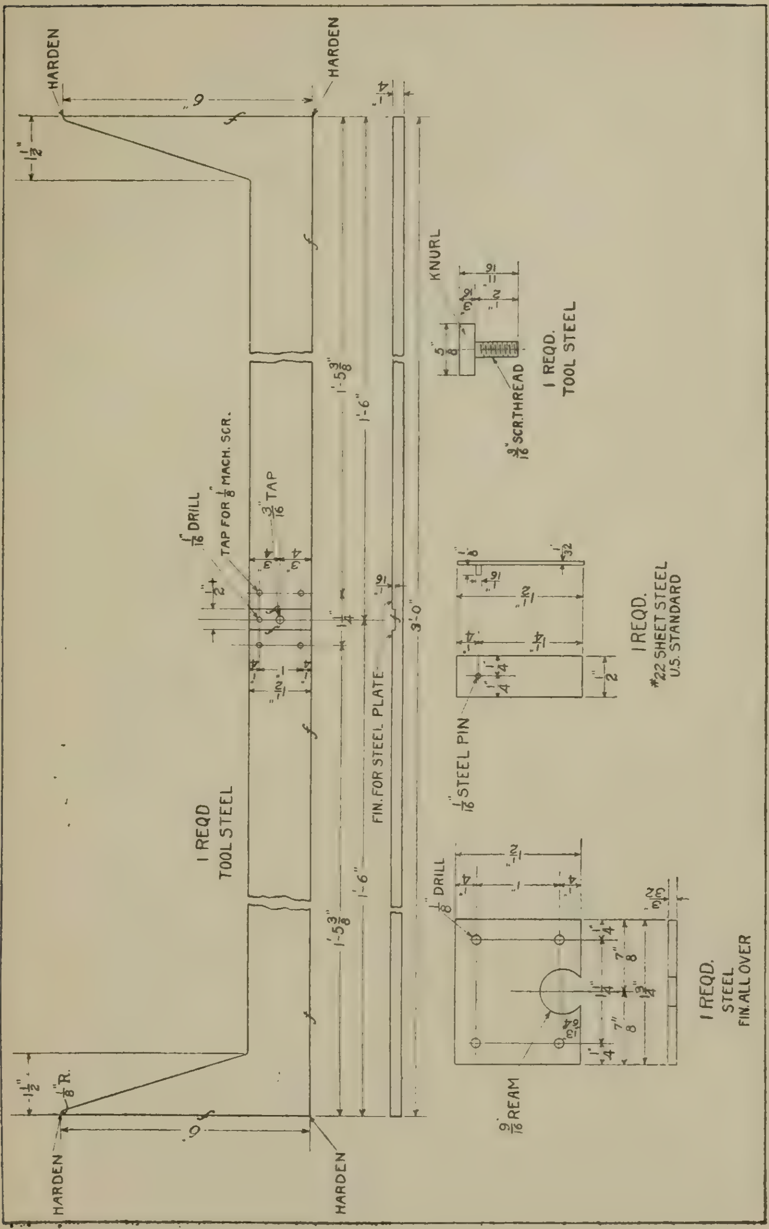


FIG. 1.—RAIL DEFLECTION GAGE.

height of 5 ft. 6 in., so that the set as a result of the first blow was about .10 in. too great and probably also by almost this amotnt in the succeeding blows. The stretch of the metal would also be somewhat greater on this account than if a blow of exactly 5 ft. had been given.

TABLE 3—DROP TEST—6,000-LB. TUP AT 5 FT.

No. of Blows.	—Set— Head Side.	Base Side.	One-inch marks after blow 1.	2.	3.	4.	5.	6.
1	1.24	1.18	1.02	1.03	1.04	1.04	1.04	1.03
2	2.09	1.96	1.04	1.05	1.08	1.09	1.09	1.06
3	2.92	2.70	1.06	1.08	1.13	1.14	1.12	1.08
4	3.70	3.39	1.07	1.09	1.14	1.17	1.18	1.14
5	Broke		1.07	1.09	1.14	1.19		1.14

Two tests with the 6,000-lb. tup, using a height of 15 ft. and giving one blow in each case, gave results shown in Table 4. Neither rail was broken.

TABLE 4—DROP TESTS—6,000-LB. TUP AT 15 FT.

No. of Blows.	—Set— Head Side.	Base Side.	One-inch marks after blow 1.	2.	3.	4.	5.	6.
1	3.21	2.96	1.08	1.12	1.16	1.16	1.12	1.08
1	3.17	2.91	1.08	1.12	1.16	1.15	1.12	1.08
Av.	3.19	2.94						

One test was made with the 60,000-lb. tup giving one blow at 5 ft. and two blows at 10 ft., with results as shown in Table 5.

TABLE 5—DROP TESTS—6,000-LB. TUP AT 5 FT. AND THEN 10 FT.

No. of Blows.	Height.	—Set— Head Side.	Base Side.	One-inch marks after blow 1.	2.	3.	4.	5.	6.
1	5 ft.	1.12	1.07	1.02	1.03	1.04	1.03	1.03	1.02
2	10 ft.	3.03	2.80	1.06	1.10	1.13	1.15	1.12	1.08
3	10 ft.	broke		1.11	....	....	1.19	1.15	....

One test was made with the 6,000-lb. tup at 20 ft., but the rail broke under the blow and of course the set could not be determined.

In addition to the above tests with the 6,000-lb. tup, one test was made with the standard 2,000-lb. tup, using a height of 15 ft., with the results shown in Table 6.

TABLE 6—DROP TESTS—2,000-LB. TUP AT 15 FT.

No. of Blows.	—Set— Head Side.	Base Side.	—One-inch marks after blow— 1.	2.	3.	4.	5.	6.
1	1.14	1.10	1.02	1.03	1.03	1.05	1.04	1.04
2	2.06	1.93	1.02	1.05	1.05	1.08	1.08	1.09
3	2.88	2.70	1.05	1.10	1.11	1.12	1.10	1.09
4	3.73	3.44	1.06	1.11	1.15	1.18	1.16	1.13
5	broke		1.08	1.15	1.19	1.24	....	1.16

In order to compare the effect of the same impact energy delivered in different ways, I give Table 7, showing the set of the under side of the rail for different energies expressed as foot-tons, one foot-ton being the energy of 2,000 lbs. dropping 1 ft. In this table I have subtracted .10 in. from the sets shown in Table 3, giving the results with the 6,000-lb. tup at 5-ft. blows, on account of the extra height given on the first blow by mistake.

TABLE 7—SETS OF UNDER SIDE OF RAIL IN VARIOUS TESTS.

Test.	—Foot-Tons— 15.	30.	45.	60.
6,000 lbs.— 5-ft. blows.............	1.08"	1.86"	2.60"	3.29"
2,000 lbs.—15-ft. blows.............	1.10	1.93	2.70	3.44
6,000 lbs.— 5 and 10 ft. blows......	1.07	....	2.80	....
6,000 lbs.—15 ft. blow..............	....	....	2.94	....

For more convenient comparison these results are plotted in Fig. 2, in which the foot-tons are shown horizontally and the set of the under side of the base vertically. It will be noted that sets caused by blows of 15 foot-tons each are about the same with the 2,000-lb. and the 6,000-lb. tups. The effect with the lighter tup shows a trifle greater, but whether there is actually this difference or whether it is due to experimental error, I cannot say. For any present purposes of our Rail Committee we may say there is no difference. When, however, we compare the set produced by 45 foot-tons delivered in one blow with the same energy divided among three blows, the set seems to be a little greater when the energy is concentrated in one blow. Three blows of the 6,000-lb. tup at 5 ft. each gave a total set of 2.60 in., while one blow at 15 ft. gave a set of 2.94 in. as the average of two tests. These few tests are not sufficient to determine the difference with precision, but it may be said that the set caused by three blows at 15 ft. of the standard 2,000-lb. tup would result from one blow of the same tup at a few feet less than 45 ft. The probable explanation for this is that within the elastic limit some of the impact energy is absorbed which does not cause any permanent set, and this has to be added to each blow before permanent deflection results. Possibly, also, the speed of impact has an influence. In calculating the height of drop which would be just sufficient to cause fracture, from the fracture produced by several blows, several feet would have to be subtracted from the summation of the several blows. This is the question for which the tests were mainly made.

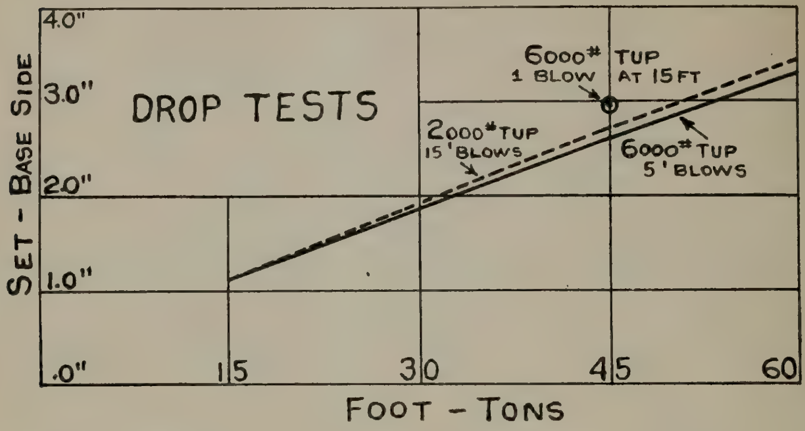


FIG. 2.—DROP TESTS WITH IMPACT ENERGY VARIOUSLY DISTRIBUTED.

FLOW OF RAIL HEAD UNDER WHEEL LOADS.

By M. H. Wickhorst, Engineer of Tests, Rail Committee.

The tests covered by this report were made to determine, if possible, what change is made in the microstructure of the head of the rail by the rolling over the rail of heavy wheel loads. At the same time, measurements were made of the spread of the head and the width of the bearing produced. The tests were made at Sparrows Point, Md., at the works of the Maryland Steel Co., who kindly furnished all the material and all the shop and laboratory facilities to make them. They were made on the reciprocating machine by moving a piece of rail back and forth under a loaded cast iron car wheel. The desire was to simulate rather severe service conditions, and a light thin head rail was used. A 70-lb. Bessemer rail was selected from stock, and in order to have material fairly uniform throughout the section and in such several pieces as might be used for test, a "D" rail, that is, the fourth rail from the top of the rail bar, was used, heat 45,437 and fourth ingot of the heat.

Two samples were taken for analysis, with a ½-inch drill, lengthwise of the rail, one close to the upper corner of the head and the other from the interior of the head at its junction with the web. The results of these analyses are shown in Table 1.

TABLE I—ANALYSES.

	Corner of head.	Junction of head and web.
Carbon	.432	.477
Phosphorus	.070	.068
Sulphur	.065	.062
Manganese	1.00	1.02
Silicon	.115	.114
Copper	.15	.18
Nickel and cobalt	.43	.41
Chromium	.26	.25

Report No. 11, January, 1911.

These results show uniform composition throughout the section, except that the carbon shows .045 per cent. higher in the interior of the section.

Samples for longitudinal tensile tests were taken from locations similar to those used for the chemical samples, duplicate samples being taken from each location, ½-in. diameter by 2-in. gage length. Duplicate samples were also taken for transverse test across the middle of the head, ½-in. diameter by 1-in. gage length. The yield point in the pieces with 2-in. gage length was determined by means of a Capp's multiplying dividers. The results of the tensile tests are shown in Table 2.

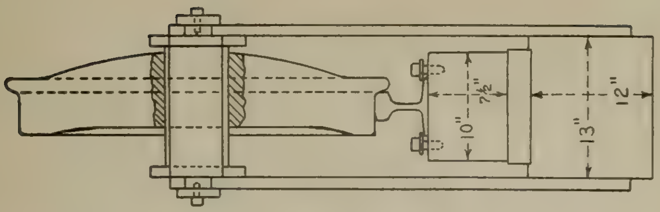
TABLE 2—TENSILE TESTS.

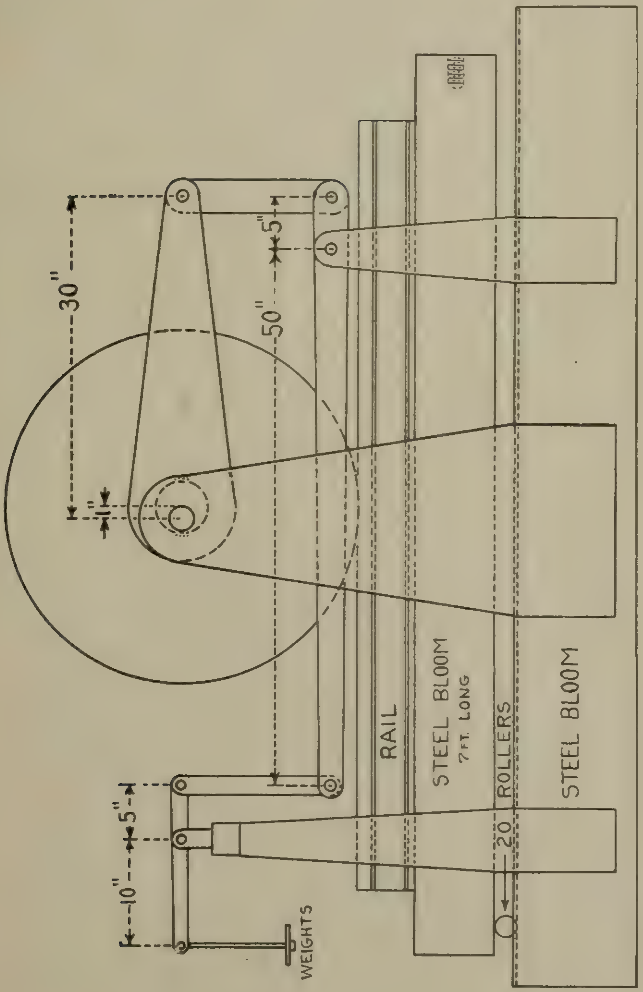
	Yield Point lbs. per sq. in.	Tensile Strength lbs. per sq. in.	Elongation per cent.	Reduction of area per cent.
Longitudinal	60,200	116,000	15	24
Corner of head...	62,800	125,000	14	22
Average	61,500	120,500	14	23
Longitudinal	63,700	116,500	15.5	22
Interior of head..	59,300	118,000	15.0	23
Average	61,500	117,250	15.3	22.5
Transverse	......	....	4	3
1-in. gage length..	......	106,000	4	14
Average	......	....	4	8.5

These results show uniform tensile properties throughout the head. One longitudinal test representing the corner of the head shows a considerably higher tensile strength than the other longitudinal tests, but, judging from all the other tensile results, it would seem that this result must be in error.

ROLLING TESTS.

Rolling tests were made with a reciprocating machine in which a piece of rail is moved back and forth under a wheel to which a load can be applied by means of levers. A diagram of the machine is shown in Fig. 1, from which it is seen that the rail is fastened to a steel bloom which runs on rollers running on another steel bloom that forms the bed of the machine. The rail bed is connected by means of a connecting rod to the bed plate of a planer, which furnishes the power to run the rail machine. The weights applied to the weight hanger are multiplied 600 times, as applied to the axle of the wheel. The piece of rail tested was 12 ins. long, which was set up between two other similar pieces, which acted as end pieces onto which the wheel could roll when leaving the piece under test. The piece tested had the sides of the head planed vertical to a width of head of 2 ins. This width was used partly to accentuate the test and partly to do away with the rounded corner, so as to allow of measuring the width closer to the top of the head, and the sides were


7½"
10"
13"
12"


30"
1"
50"
5"
5"
10"
WEIGHTS
RAIL
STEEL BLOOM
7FT. LONG
ROLLERS
20
STEEL BLOOM

made vertical so the measurements could be made satisfactorily with a micrometer along the whole depth of the head. The section of the original rail and as tested are shown in Fig. 2. Before testing the width of the head was determined at the top, at the bottom and halfway between, both at the middle of the piece tested and at one end, by means of a micrometer. To determine the sag of the head, two prick punch marks were put on each side of the rail at the middle of its length, one on the side of the head near its bottom and the other on the top side of the base, about ¾ in. from the web. In order to have a vertical side on which to prick punch the mark, the base was gouged at the desired place. The distance between the marks was measured in .01 in. by means of a fine-pointed toolmaker's dividers and a steel scale reading to .02 in.

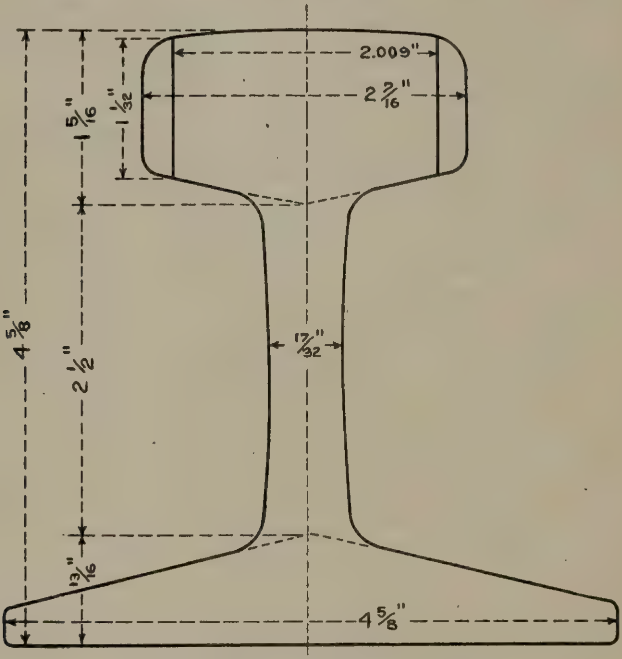


Fig. 2—Section of Rail Tested.

The test was started with a load of 30,000 lbs. applied to the wheel, using 1,000 double strokes or 2,000 rollings of the wheel over the rail under test. The bearing assumed a width of .64 in. The only effect on the width of head was to spread the top of the head .002 in., and the load was therefore increased at once to 60,000 lbs. and the test continued until the head seemed to no longer spread as measured with the micrometer. The width of the head of the rail and the width of the wheel bearing on the rail, at various stages of the test under the load of 60,000 lbs., are shown in Table 3. The spread of the top part of the head and the width of bearing in this table includes also the effect of the preliminary rolling of 2,000 wheel applications with 30,000 lbs. The head did not show any sag throughout the test.

TABLE 3—ROLLING TESTS WITH LOAD OF 60,000 LBS.

		Spread of Head.					
		Middle of rail.			End of rail.		
Wheel Rollings.	Width of bearing.	Top of head.	Middle of head.	Bottom of head.	Top of head.	Middle of head.	Bottom of head.
200	.92	.002	.000	.000	.004	.002	.000
2,000	.92	.009	.003	.000	.006	.002	.000
4,000	.94	.010	.004	.001	.006	.002	.000
23,460	1.02	.013	.006	.001	.008	.003	.000
32,142	1.04	.013	.006	.001	.008	.003	.000

It should be remarked that the wheel was beveled some, and the bearing was therefore on one side of the top of the head, remaining throughout about .2 in. from one side and increasing in width toward the other side.

The results showing the spread of the head are plotted in Fig. 3, the number of rollings being shown horizontally and the spread of the head vertically in .001 in. Between rollings 4,000 and 23,460 the machine was run during the night, without readings being taken, and therefore the curves between these points undoubtedly show flatter than they should. It will be noted that the top of the head finally spread .013 in. at the middle of the piece tested which was 6 ins. from the end, and at the end of the rail it spread .008 in. This difference of a less spread at the end was

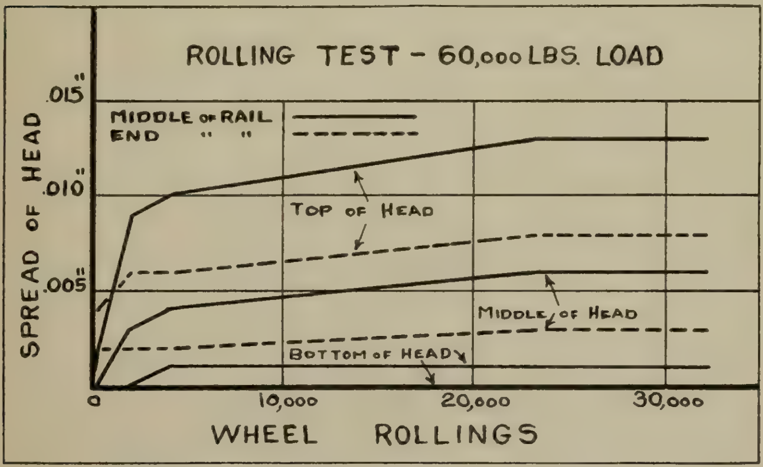


Fig. 3—Rolling Test Showing Spread of Head.

unexpected, but it remains for future tests to determine what the normal relationship is between the body of the rail and the end as regards spreading. It is also interesting to note that the end spread more in the first few rollings. At the middle of the depth of the head, the spread was a little less than half what it was at the top, it being here also less at the end than at the middle of the rail. At the bottom of the head, which was a little over 1 in. thick, the spread seems to have been just perceptible at the middle of the rail, the increase showing .001 in., but no spread could be detected at the end of the rail. These results indicate that although the spread is greatest at the top of the head, the lateral extension occurs through almost or quite the whole depth of the head. It is also seen that under the conditions of this test and with the load and material used, about .8 of the maximum result was produced by the first 5,000 rollings, and almost the maximum by the first 10,000 rollings. The 22,000 rollings beyond this produced but little additional spreading of the head.

MICROSCOPIC TESTS.

Microscopic examination was made of the rail at the top of the head and at the center of the head, both before rolling and after rolling. Before rolling a section about ¼ in. thick was taken from near the rail to be tested and two pieces cut from it for microscopic test, as shown in Fig. 4. After rolling, a ¼-in. section was cut from the middle of the rail tested and similar small pieces were cut from it for microscopic test. These pieces were polished on three sides, etched with 10% solution of nitric acid in alcohol and microphotographs made, magnified 50 diameters. Thus,

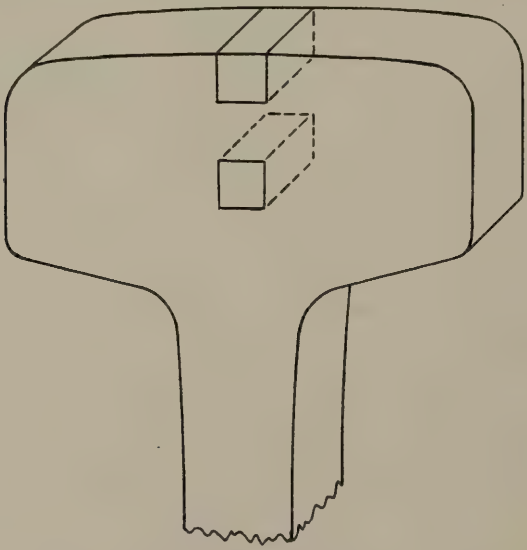


FIG. 4—PIECES FOR MICROSCOPIC TESTS.

horizontal, vertical transverse and vertical longitudinal sections were obtained at the top and at the center of the head both before and after rolling. The twelve microphotographs are shown in Figs. 5 to 16, inclusive. In general, it may be said that the pictures indicate a slight stratification of the grains in a longitudinal direction, but there is little, if any, difference between the specimens before rolling and after rolling. The material tested was good ductile material of medium hardness for rail steel, and as the maximum lateral stretch at the top of the head was only .013 in., much difference in the miscrostructure could hardly be expected. The two views giving top views of the material at the top of the head show a much finer structure than the others and also show a larger area of the white ferrite web work, showing lower carbon right at the surface.

One purpose in making these tests was to standardize the reciprocating test, if possible, so as to be able to compare different materials under the standard conditions of test, and to be able to compare the results of tests made at different times. The Sub-Committee on Tests would therefore be very pleased to receive suggestions toward this end.

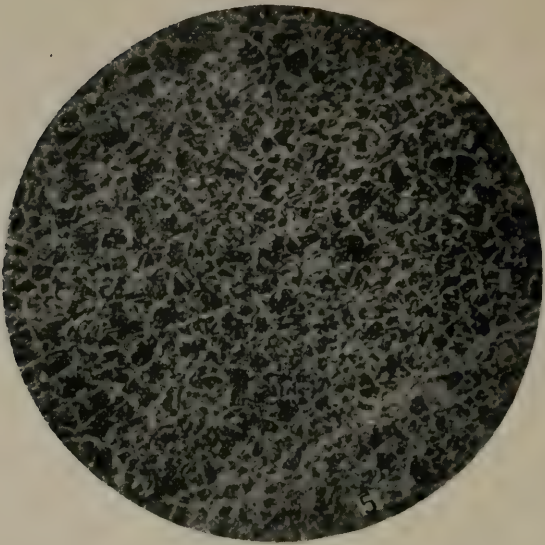


Fig. 5.—Top View at Top of Head, Before Rolling.

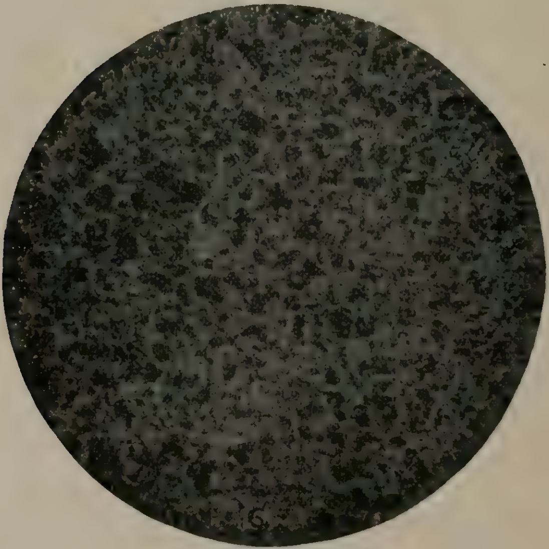


Fig. 6.—Top View at Top of Head, After Rolling.

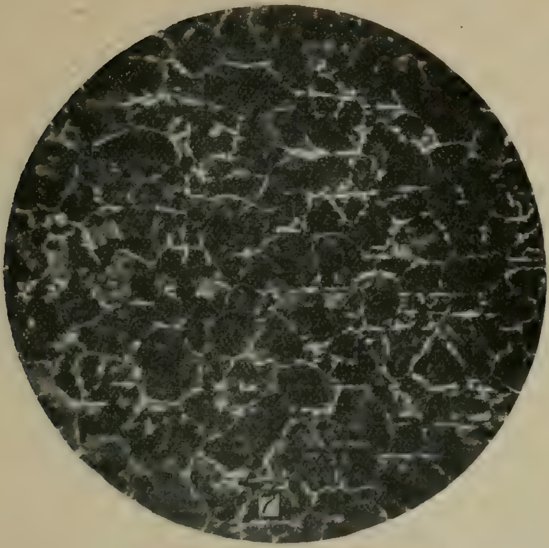


Fig. 7.—Top View at Center of Head, Before Rolling.

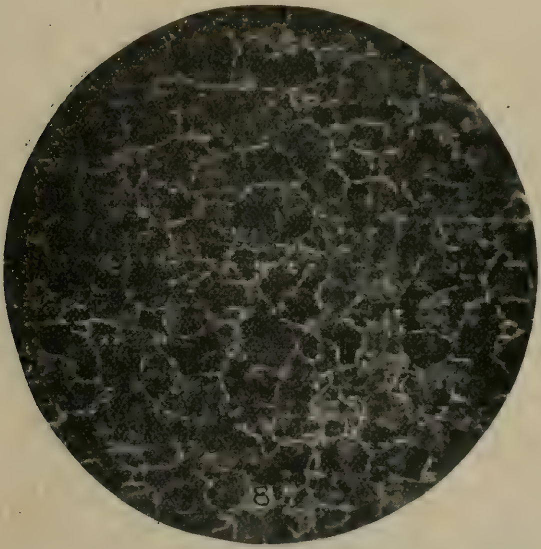


Fig. 8.—Top View at Center of Head, After Rolling.

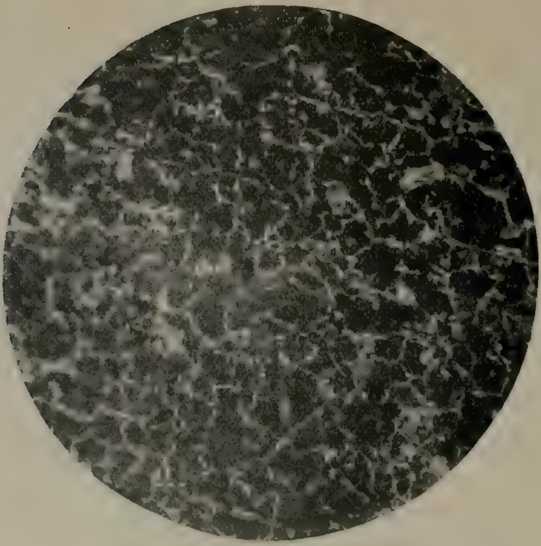


FIG. 9.—SIDE VIEW AT TOP OF HEAD, BEFORE ROLLING.

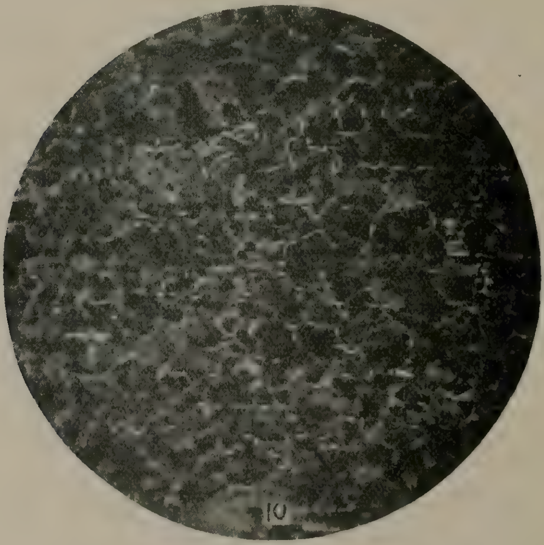


FIG. 10.—SIDE VIEW AT TOP OF HEAD, AFTER ROLLING.

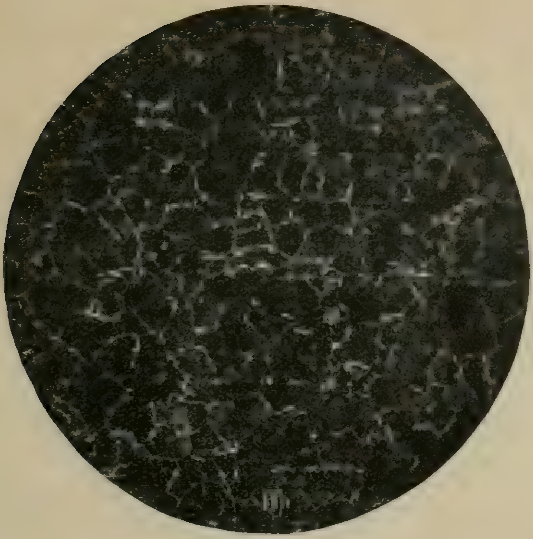


FIG. 11.—SIDE VIEW AT CENTER OF HEAD, BEFORE ROLLING.

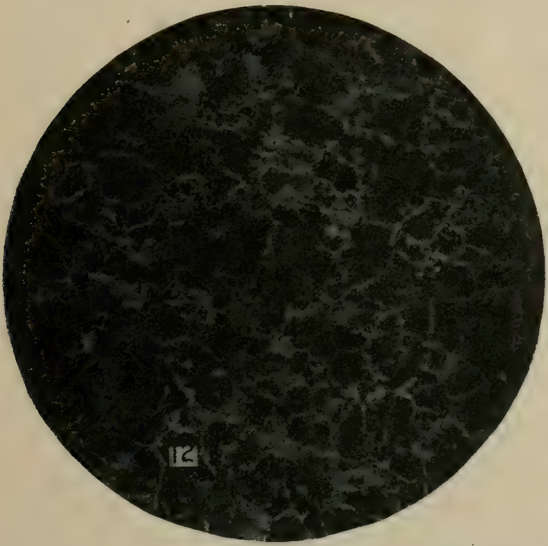


FIG. 12.—SIDE VIEW AT CENTER OF HEAD, AFTER ROLLING.

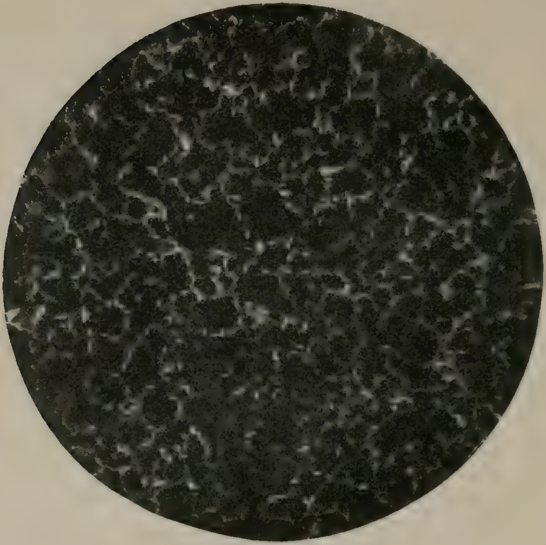


FIG. 13.—TRANSVERSE VIEW AT TOP OF HEAD, BEFORE ROLLING.

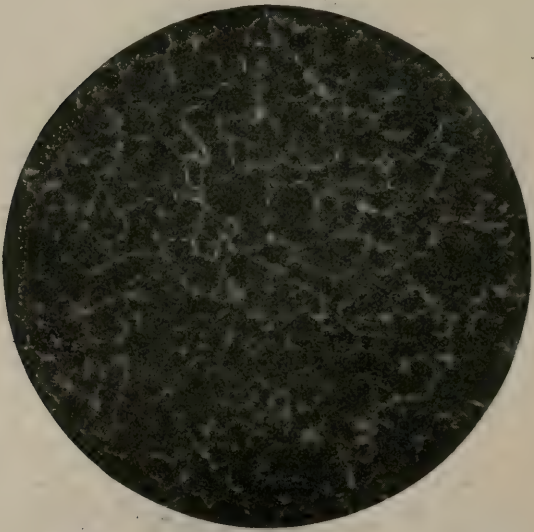


FIG. 14.—TRANSVERSE VIEW AT TOP OF HEAD, AFTER ROLLING.

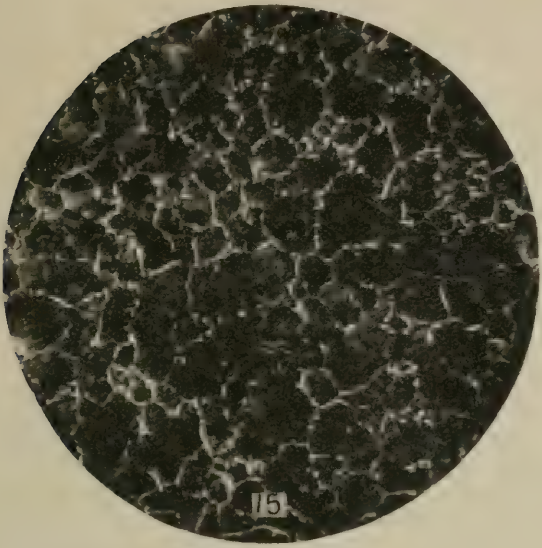


Fig. 15.—Transverse View at Center of Head, Before Rolling.

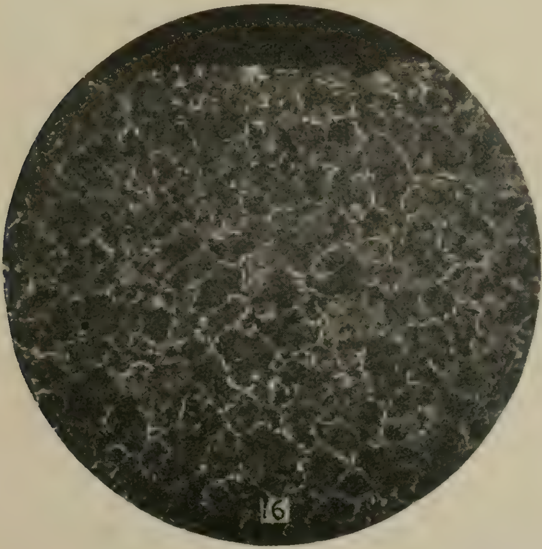


Fig. 16.—Transverse View at Center of Head, After Rolling.

Appendix F.

DUCTILITY TESTS OF RAILS

UNDER SPECIFICATIONS OF THE NEW YORK CENTRAL LINES.

By Dr. P. H. Dudley, Consulting Engineer.

I am enclosing herewith tests of four different melts of open-hearth steel rails, 100-lb. Dudley 6-in. section, made in accordance with the specifications for the New York Central Lines. These specifications require that three separate butts of each melt, one taken from the second, the tenth and the ingot before the last, that the maximum elongation per inch of each must show six per cent. (6%), or two consecutive inches five per cent. (5%), each under the 20-ft. drop. Should all of the butts break, yet each give the required elongation, the melt would be accepted, but should a single butt break without giving the specified elongation the melt would be rejected.

The butts before testing under the drop are stamped upon the base with a spacing bar of seven conical points, which gives six 1-in. spaces. These are measured after the drop test by a flexible steel rule divided into one-hundredths of an inch. The increase in hundredths of an inch per inch of the original spaces gives the percentage of elongation for a single blow. To exhaust the entire ductility of the steel two or more blows are usually required to break the section.

The first melt shown on the enclosed tests, dated 11-9-10—No. B-21596, covered 26 ingots and 104 rails. The butt, top crop, twenty-fifth ingot, the permanent set under the drop of 2,000 pounds falling 20 ft. was 1.25 in., and three consecutive inches gave an elongation of five per cent (5%), the total for the 6 in. being .25 of an inch.

The second test, melt No. B-21596, butt 11-2, top crop, second ingot, the permanent set was 1.20 in. and the two consecutive inches gave the five per cent. (5%) elongation.

The third test, melt No. B-21596, butt X-3, top crop, tenth ingot, the permanent set was 1.20 in. with two consecutive inches, giving five per cent. (5%) elongation under a single blow. The ductility of that butt was completely exhausted, the maximum inch breaking at seventeen per cent. (17%). The carbon by combustion was 0.692.

Report No. 16, February, 1911.

The next melt, No. B-15557, covered 19 ingots and 76 rails. The butt from the second ingot, 11-3, was used to exhaust the ductility of the melt. Two inches gave eighteen per cent. (18%). The carbon was 0.632, slightly lower than the first melt mentioned.

The next melt, No. B-14719, covered 25 ingots and 100 rails, the carbon being the same as the preceding melt with lower manganese, and was rolled colder than the preceding melts, or colder than the general average. The first butt tested, which was from the last but one of the ingots poured from the melt, gave the required elongation, but broke. The tenth ingot, X-2, gave the required elongation. The third butt from the second ingot, with a permanent set of 1.30 in., gave a trifle more than the required ductility, but broke on the second blow without increasing the maximum elongation. The melt just met the requirements of ductility to be accepted.

The melt rolled 11-3-10, No. B-16653, the butt broke with a limited permanent set, only giving two per cent. (2%) elongation per inch for 4 in. This was of itself sufficient to reject the melt. The second butt only gave five per cent. (5%) elongation in a single inch, having a permanent set of 1.05 in. The third butt with a permanent set of 1.10 in. gave 1 in. of 5 per cent. elongation, and upon the second blow it was not increased, but broke.

This steel, rolled in five-rail lengths, occupied so much time in passing through the rolls that it became too cold for proper working, and it was found necessary to reduce the ingots to four-rail lengths to insure that, with the number of passes and direct rolling from the ingot, the ductility of the steel of 12 to 18 per cent. provided by the composition would not be reduced under 5 per cent. in two consecutive inches and cause the melt's rejection. After the ingots were poured in four-rail lengths, the time for roughing and finishing the bar was reduced about two minutes, with such a gain in ductility of the metal that afterwards out of about one hundred and eighty melts only one was rejected. These results have been confirmed by another manufacturer, who rolls open-hearth rails direct, and found that he must make a considerable reduction in the carbon from that expected to retain the required ductility of the steel as a girder.

The rolling of these rails was started two days earlier than first arranged, and, owing to prior engagements, I was not able to be present personally until the third day. It required only a few moments to ascertain the causes of the reduced ductility, viz.: slightly higher carbon, as shown by the combustion tests, than the color tests indicated, and cold rolling, but by correcting those conditions in accordance with the following clause in the specifications the normal ductility in the rails was obtained:

"To adjust the chemical composition to the special conditions of manufacture at each mill the engineer representing the railroad company, from the inspection of the ingots, their heating, blooming and rolling into rails, shall have the right to select the lower or average limit of either the silicon or manganese, or both, with the average carbon content as the working basis for making the steel, as he may find requisite for good setting ingots with freedom from pipes and rolling into tough steel by the plant of the manufacturer."

This experience leads me to the conclusion that all carbon determinations for melts of open-hearth rails should be made by combustion rather than by color tests.

The requirements of most specifications that the steel shall pass after a single drop test without any measurements of the elongation does not give sufficient definite information as to the average ductility of the metal to be of the greatest value in manufacture. It should be exhausted in the section by one or more blows of the drop to determine its minimum or maximum values.

Rail butts often shear near the supports after giving 4 or 5 per cent. ductility, and can as safely be accepted as those rails which pass a drop yet break in the center upon the second blow, but do not give additional elongation.

Nearly 600,000 tons of Bessemer 0.06 low-phosphorus rails with 0.60 to 0.65 carbon were made under specifications which stated that ninety per cent. (90%) of the butts should stand a drop test of 2,000 pounds falling 20 ft., and that any of the butts which broke but gave four per cent. (4%) elongation, the heats would be accepted. Those rails did not subsequently break in the track.

Rails with phosphorus 0.10 and carbon only 0.50 it is necessary now for high-speed service under low temperatures to increase the average percentage of elongation by at least 1 or 2 per cent. The present acceptance of rails from a single blow of the drop means for the 100-pound sections for a deflection of 1.3 to 1.5 of an inch that the maximum ductility of many of those heats would not exceed six per cent. (6%) per inch, and a specification which would accept a few heats which broke at five per cent. (5%) elongation, but exhausted the ductility in many of them to ascertain its general range, would be better for requisite information in the manufacture of rails than the specifications which control only by the single drop test.

The photomicrographs of some of the cold rolled rails of only 0.70 in carbon show that the ferrite is all absorbed, and the perlite is without the least orientation by lines of ferrite, but with higher carbon cementite surrounds the perlite.

The advantage of knowing the ductility of the steel as soon as manufactured can be utilized to guard and control the subsequent daily fabrication, either as to chemical composition or the heating and rolling.

The fact now is understood that rolling open-hearth rails direct from the ingot, the carbon in the chemical composition cannot be as high as can be used by mills which bloom the ingots, then reheat to finish the rails.

Specifications for open-hearth rails should permit sufficient range in the chemical composition for the various sizes of the ingots and the difference in rolling, whether direct or the blooms are reheated.

INFLUENCE OF COLD ROLLING ILLUSTRATED.

Very few photomicrographs of open-hearth rails, in which the low content of carbon has reached the saturation point for the chemical composition as influenced by cold rolling, have been published. Four such photomicrographs of open-hearth and two of Bessemer cold rolled rails which have a limited ductility are herein presented with the following descriptions:

Open-Hearth, 6-in. 100-lb Rail, Dudley Section, Half-Moon or Cresent Break:

This rail was rolled cold and the test of the B. crop, 20 per cent. discard, had a ductility of only 5 to 6 per cent. per inch under the drop, while the fractured rail is less. Carbon 0.68, Manganese 0.72, Phosphorus 0.02 and Silicon 0.15. The steel with this amount of carbon was completely saturated and structure is all perlitic. No free ferrite is shown. A few of the white, sharp points are possibly cementite. The melt was rolled 7-1909.

A photomicrograph of a transverse and a longitudinal section is shown of the metal near the edge of the flange. Fig. 1 is the transverse view, and Fig. 2 the longitudinal. Fig. 3 is a photomicrograph of the transverse section near the center of the base of the rail. Fig. 4 is a longitudinal section in the same locality. These both also show a perlitic structure, but with a lesser portion of dark areas than Figs. 1 and 2.

Plain Bessemer, 80-lb. 5⅛-in. Dudley Section, Heat No. 6575-C:

Carbon 0.50, Manganese 0.95, Phosphorus 0.097, and Silicon 0.13. Fig. 5 is a photomicrograph of the edge of the flange of a transverse section, rolled cold. Fig. 6 is a photomicrograph of the longitudinal section from the same location. Four rails broke from this heat, "A," "B," "C" and "D." These rails were rolled in a four-length ingot, and the photomicrographs were made from the "C" rail.

The ferrite is abundant in the structure, but without distinctly enclosing the perlite grains. The fracture is vitreous and fragile in low temperatures. The number of grains at the center of the base of the rail ranged from 80,000 to 100,000 per square inch.

ELONGATION AND DUCTILITY TESTS UNDER THE DROP.

Date	Melt No.	No. of Ingots	No. of Rails	Perm. Set	Elongation per Inch							Remarks
					1	2	3	4	5	6	Total	
11-9-10 Chemical	Composition:	C. .692, Mn. 1.03, Ph. .032, Sul. .043, Si. .126.										
X1-1	B-21596	26	104	1.25	1.04	1.05	1.05	1.05	1.04	1.02	6.25	Acc.
11-2	B-21596			1.20	1.04	1.05	1.05	1.03	1.03	1.02	6.22	Acc.
X-3	B-21596			1.20	1.02	1.05	1.05	1.04	1.04	1.03	6.23	Acc.
	B-21596			2.15	1.06	1.07	1.08	1.08	1.07	1.06	6.44	Acc.
	B-21596			3.00	1.08	1.10	1.14	1.16	1.12	1.08	6.68	Acc.
	B-21596			Broke	1.08	1.12	1.16	1.17	1.13	1.09	6.75	Acc.
11-9-10 Chemical	Composition:	C. .632, Mn. 1.02, Ph. .020, Sul. .040, Si. .174.										
X1-1	B-15557	19	76	1.25	1.04	1.05	1.05	1.05	1.04	1.03	6.26	Acc.
X-2	B-15557			1.20	1.04	1.05	1.05	1.04	1.03	1.02	6.23	Acc.
11-3	B-15557			1.20	1.03	1.05	1.05	1.05	1.04	1.03	6.25	Acc.
	B-15557			2.10	1.10	1.10	1.09	1.08	1.05	1.03	6.45	Acc.
	B-15557			3.00	1.14	1.17	1.16	1.10	1.06	1.04	6.67	Acc.
	B-15557			Broke	1.15	1.18	1.18	1.12	1.07	1.05	6.75	Acc.
11-9-10 Chemical	Composition:	C. .632, Mn. .88, Ph. .031, Sul. .041, Si. .104.										
X1-1	B-14719	25	100	Broke	1.04	1.05	1.06	1.04	1.05	1.03	6.27	Acc.
X-2	B-14719			1.30	1.04	1.06	1.05	1.05	1.04	1.02	6.26	Acc.
11-3	B-14719			1.30	1.04	1.05	1.06	1.06	1.04	1.03	6.28	Acc.
	B-14719			Broke	1.04	1.05	1.06	1.06	1.05	1.04	6.30	Acc.
11-3-10 Chemical	Composition:	C. .750, Mn. 1.02, Ph. .020, Sul. .030, Si. .158.										
1	B-16653			Broke	1.01	1.02	1.02	1.02	1.02	1.01	6.10	Rej.
2	B-16653			1.05	1.02	1.04	1.05	1.04	1.04	1.03	6.22	Rej.
3	B-16653			1.10	1.02	1.04	1.04	1.05	1.04	1.02	6.21	Rej.
	B-16653			Broke	1.02	1.04	1.04	1.05	1.04	1.02	6.21	Rej.

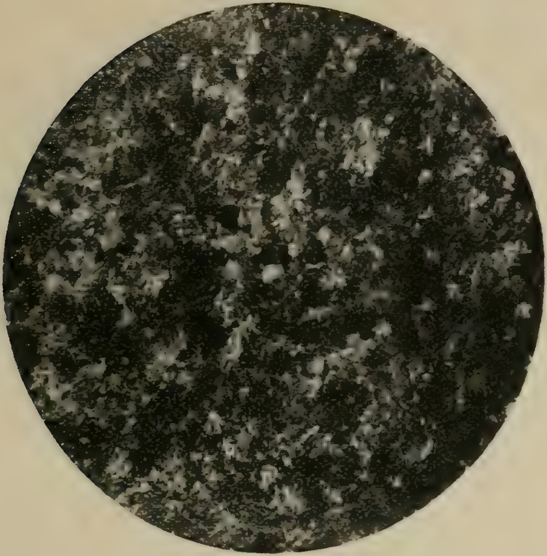


FIG. 1.

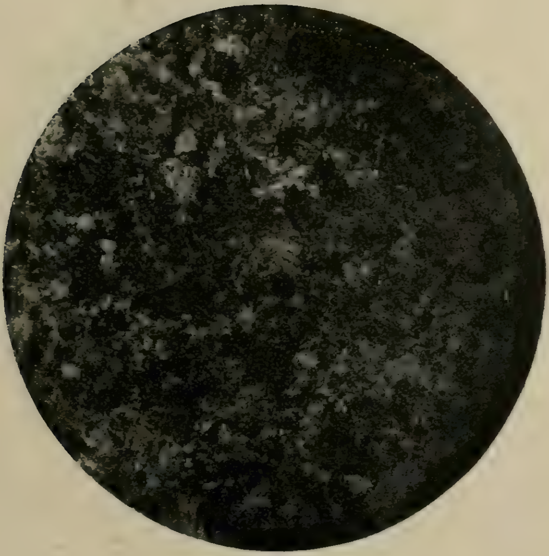


FIG. 2.

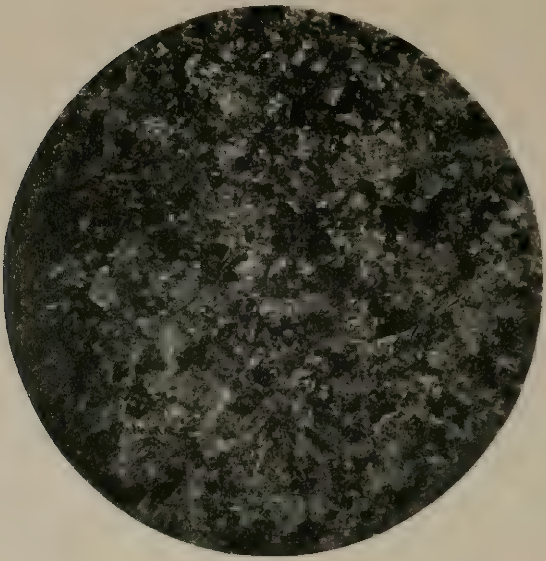


FIG. 3.

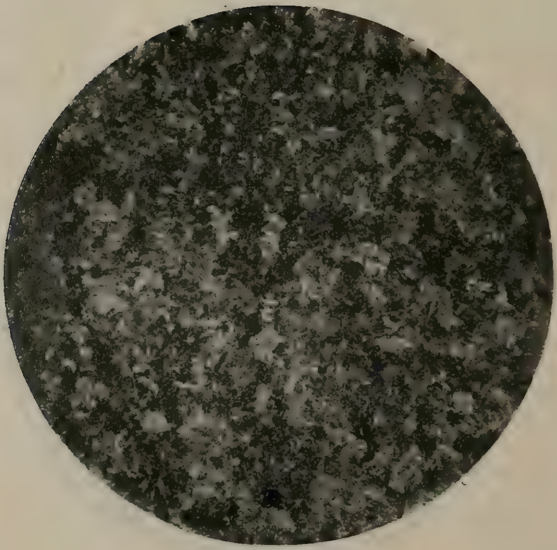


FIG. 4.

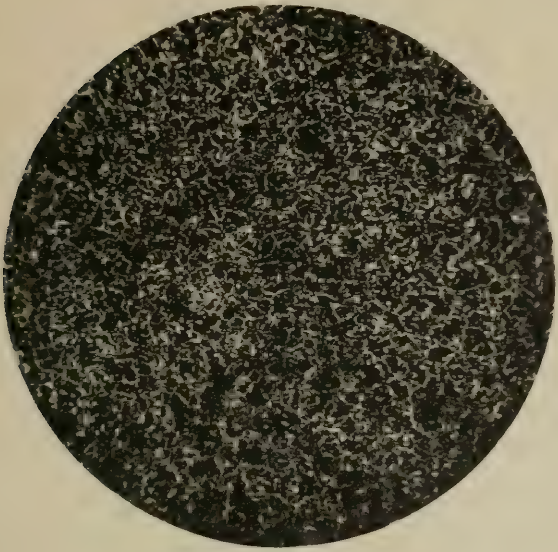


Fig. 5.

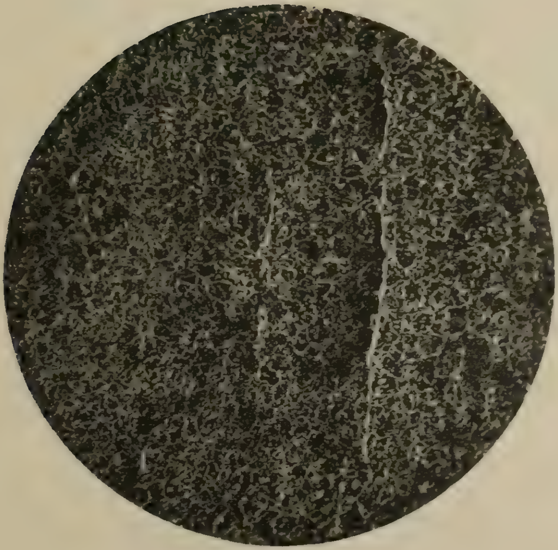


Fig. 6.

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